Automated panoramic thermal imaging sensor

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A high-resolution sensor with 360° coverage automatically detects and tracks warm moving objects and is designed to act as an intelligent node in a sensor network.

We are developing the Automated Panoramic Thermal Imaging Sensor (APTIS)—a device with a 360° field-of-view (FOV)—to provide instantaneous full-horizon detection, location, and tracking of multiple targets.1 The ViperView™ optical design of the imager allows for small size and low cost, combined with the high matching-pixel resolution of state-of-the-art uncooled thermal-infrared sensors.

Catadioptric panoramic optical systems—systems that include both lenses and mirrors—have limited resolution, especially working at large apertures, related to their optical components. Unless the aberrations of the lenses and mirrors are corrected, the image spot size may significantly exceed the pixel size of the sensor, compromising the investment in a high-resolution infrared imaging device. With optics-limited resolution, such panoramic cameras cannot benefit from these sensors. The detrimental effect of aberrations is more pronounced at the high lens apertures required in low-light conditions and in the long-wavelength infrared (LWIR) range.

The small, high-resolution optics used in ViperView have been designed to match the focal plane array 640×480 LWIR imager used with it to perform day/night detection of personnel, aircraft, and vehicles, even when camouflaged. The system was designed to minimize the size of the optics while maintaining a sensor-limited resolution and the desired vertical field of view. This high resolution allows for longer target detection and identification ranges, and reduced target acquisition times. In addition, the novel combination of the imager with 360°-FOV optics will enable accurate target bearing, temperature profiles, and rough order-of-magnitude target imaging that can aid classification, discrimination, and identification of targets.

The APTIS system features automatic, intelligent video processing for detection, location, and tracking of multiple targets.

Several processing modes and rules for detection and tracking are available. The software is capable of separating meaningful target motion from motion clutter, such as produced by trees, shrubs, and similar natural objects. A primary target can be identified according to different criteria while information on additional targets is also served continuously, so allowing multiple target tracking. In the thermal imagery produced by the ViperView camera, the target intensity and color (shade of gray) characterize the thermal signature of the target. This important characteristic is used for target detection and tracking along with other selection criteria. The target detection is fast—in the region of a fraction of a second—for both new targets and those reappearing after hiding or being obstructed.

The integrated sensor includes a GPS receiver, an electronic compass, and a tilt sensor to provide the exact location and orientation of the camera. This is communicated to the client com-

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Figure 2. Shown is the ViperView™ experimental prototype.

Figure 3. ViperView captures images with pixel-limited camera resolution.

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computer along with the video and target data, so that every pixel in the camera defines a known direction to target from a known point where the camera is located.

Communications between the server and the client—an embedded computer on the camera end and the operator’s rugged notebook computer, respectively—are established through a secure wireless network. With a moderate-size antenna, the system operates up to four miles in light-of-sight conditions. The signal between the RF modules is encrypted for secure transmission. This wireless capability allows the imager to serve as an advanced sensor node in a network of intelligent, distributed-sensor arrays.

To reduce the power consumption, all of the hardware on the camera side can be sent into hibernation at the operator’s command. Wakeup of the APTIS server is provided by an ultra-low-power wireless wakeup device. The uncooled imaging sensor means the system has instant-on capability.

In summary, development of the Automatic Panoramic Thermal Imaging Sensor is underway. The sensor is designed to operate as an intelligent node in an ad-hoc sensor network. The system features automatic detection, location, and tracking of multiple targets and advanced power management for extended battery life, enabled by remote wakeup capability. The small ViperView panoramic camera has high resolution to match the pixel-limited resolution of today’s state-of-the-art thermal imaging sensors.

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References


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