Advanced Sensor Fusion Combined with Intruder Deliberate Motion Analytics

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Physical Security Pathway

Goals of LWRS Program's Physical Security R&D activities are to develop and deploy advanced technologies and provide the technical basis for optimizing physical security performance and reduce costs at nuclear power plants. One area of research includes sensor fusion linked with Deliberate Motion Analytics (DMA) which can take input from multiple sensors of different types, analyze the data, and determine if an adversary is approaching a facility. Sites using current commercial sensor technologies experience nuisance alarm rates (NAR) not caused by an intruder. Maintaining a low NAR while being able to detect intruders has the potential to decrease the cost of security at a nuclear power plant.

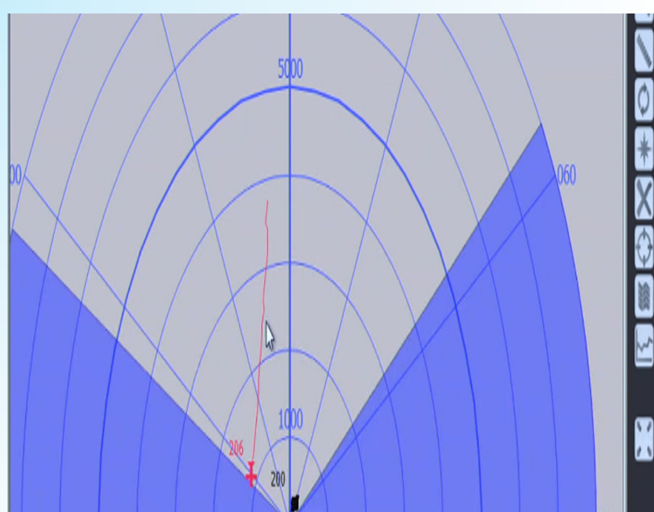
Figure 1 is a screenshot from radar during a 10-minute light rain shower, showing approximately 100 nuisance alarms. The high NAR makes it difficult for the security operator to identify a real intruder. One solution to reducing high NAR is to use DMA, the expected results are shown in Figure 2.

In collaboration with Management Sciences, Inc., LWRS Program researchers at Sandia National Laboratories have developed a sensor algorithm that uses deliberate motion to differentiate alarms caused by an intruder from those caused by other natural occurrences. DMA is capable of fusing multiple, complementary sensors, such as radar, Light Detection and Ranging (LiDAR) and video, to provide reliable detection. DMA allows elevated detection sensitivity to be set, enabling detection of stealthy intruders, but only declaring an alarm when deliberate motion toward a site is indicated. This technology will enable new security architectures and is estimated to reduce perimeter intrusion detection costs by 40%.

DMA is a multiple intelligence fusion algorithm for intrusion detection and tracking using a distributed, multi-layer tracking and classification algorithm. DMA's motion pattern recognition algorithms have demonstrated the ability to identify potential intruders inside and outside the perimeter intrusion detection system, successfully issuing alarms against positive tracks while filtering out background noise and non-threatening tracks from weather, foliage, and background traffic. When DMA determines a track to be a threat, an alarm is communicated using the standard dry contact switch, a typical alarm indication for commercial-off-the-shelf monitoring systems, making it easy to integrate with existing alarm monitoring systems. A bi-spectral pan-tilt-zoom camera slews to the DMA alarm location, thereby providing an image of the intruder to the alarm monitoring officer day or night negating the need for perimeter lighting.

Figure 1. Nuisance alarms generated during a light rain shower.

Figure 2. Expected results from DMA.



DMA's performance is based on its ability to recognize background noise and perform motion behavior analysis to focus and filter alarm indications from multiple sensors, such as filtering through the high NAR generated by video analytics scanning a grass field during windy conditions. DMA applies motion behavior analytics by aggregating the alarm position, track trajectory, and velocity of potential intruders as reported by multiple sensor hits. DMA exploits the concept of complementary sensor phenomenology, allowing the fusion of multiple complementary sensors whose strengths augment the weaknesses of another. Specifically, it combines sensor inputs in a way that allows sensors to augment physics-based limitations (e.g., an imager looking into the sun will not detect an intruder, but a radar will).

The two figures below show real-time DMA fusion of radar and thermal radar examples at a testbed at Sandia's Sensor Test and Evaluation Center. Figure 3 shows numerous raw radar hits (blue dots) and raw thermal radar hits (yellow dots) inside and outside a typical two-fence perimeter design. In this scenario, DMA does not declare an alarm, designated by the "No Alarm" indicator in the green circle. Figure 4 shows DMA declaring an alarm when quality tracks are formed by both radar and thermal radar and shows deliberate motion toward the secure side of the perimeter, designated by the dual-track and the "Alarm" indicator in the red circle. DMA algorithm decides when to fuse data from all sensors or only use alarm data from a specific sensor, enabling it to be much more adaptive and effective in noisy environments.

DMA is designed to be sensor agnostic, meaning it should be able to fuse sensor outputs from emerging and traditional intrusion detection sensors, including radar, LiDAR, thermal radar, video, microwaves, and buried line sensors. To date, the following sensors have been fused using DMA: radar and video analytics from cameras and thermal imagers; radar and thermal radar, and video analytics and a buried line sensor.

Test data collected to date include:

- Testing inside a traditional two-fence perimeter, fusing radar and video analytics over a period of six months yielded one nuisance alarm. DMA fused sensor system met U.S. DOE detection requirements.
- Testing beyond the fence in un-engineered terrain with 3 ft. changes in elevation and native foliage in a high desert environment yielded no nuisance alarms for 28 hours, where an estimated 160,000 raw sensor alarms were generated. DMA fused sensor system met DOE detection requirements. These are preliminary results due to the relatively short NAR collection period.

More nuisance alarm data should be collected in different environments before conclusively demonstrating DMA's capabilities. Current plans are to test DMA fused sensor systems during the winter at a northern state's nuclear power plant site and during the summer in a southern state's nuclear power plant site. The application of DMA and sensor fusion into LWR physical security strategies represents and enabling technology that will reduce nuisance and false alarms with high levels of detection performance, enabling optimized physical security designs and significant reduction of security costs.

Figure 3. DMA shows "No Alarm."

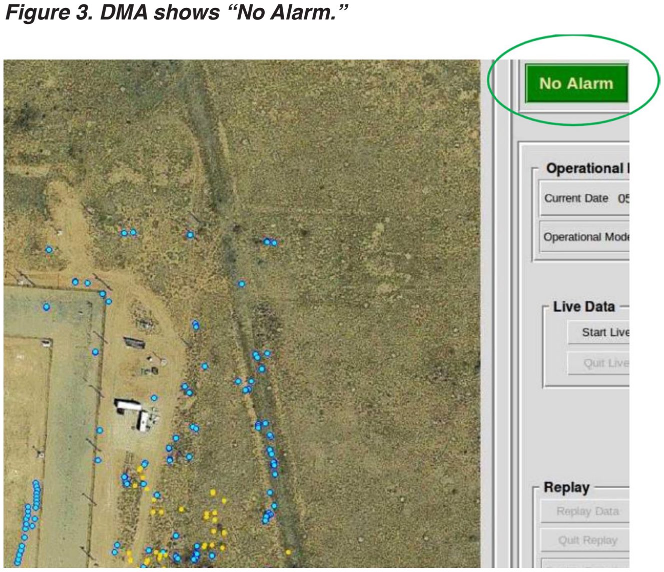


Figure 4. DMA shows "Alarm."