CASE STUDY

AI-Assisted Machine Vision

Fighting Illegal Poaching with a Purpose-Built AI Camera

Smart cameras with Intel AI technology can help protect endangered wildlife from poachers by triggering a real-time alert system when the camera's AI algorithms detect humans within captured photos. The Intel® Movidius™ Myriad™ 2 vision processing unit (VPU) powers the TrailGuard AI* vision processing and on-camera inference—all while operating at very low power to enable an estimated year-long battery life.

"The Intel® Movidius™ Myriad™ 2 VPU has enabled us to build an intelligent sentinel for practically every corner of Africa's iconic wildlife parks. AI-driven smart cameras will transmit images in near real time to help park rangers identify poachers and stop them before they can kill."

— **Eric Dinerstein,** Director Wildlife and Biodiversity, RESOLVE

Fighting Africa's illegal poaching trade is difficult and dangerous; saving the lives of animals from poachers is even harder. The world's overall population of African elephants drops by one animal every 15 minutes. From a peak population of more than two million, the last 100,000 African forest elephants alive today are on track to be eliminated by poaching for ivory and bush meat within the next decade.

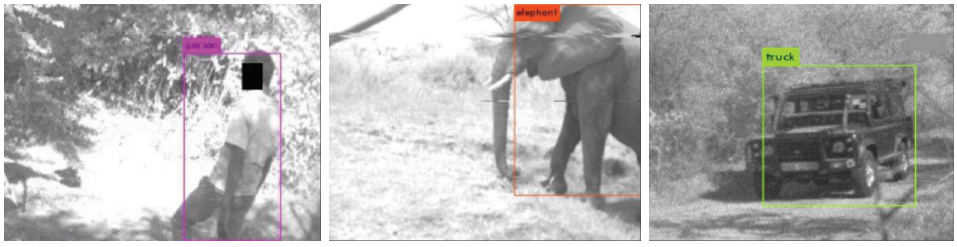
Staff limitations at Africa's national parks make it all the more difficult to catch poachers. For example, Serengeti National Park has 150 rangers to cover a park that's roughly the size of Belgium, making it impossible to effectively patrol all of the access trails that poachers use.

This is the tragic reality that drove the non-governmental organization RESOLVE in search for a solution to the problem, "How can we stop poachers before they kill?" RESOLVE works to forge sustainable solutions to challenges in the areas of natural resources, the environment, and public health.

The RESOLVE team turned to the latest in smart vision technology from Intel to develop TrailGuard AI*, a purpose-built smart camera. At a size no larger than a human index finger, TrailGuard AI can be easily hidden in the bush.

Based on the Intel® Movidius™ Myriad™ 2 vision processing unit (VPU), the camera wakes when it detects motion, uses an on-device AI algorithm to analyze images in real time, and alerts park headquarters with a photo when humans or vehicles are identified in any of the captured frames.

The use of artificial intelligence and real-time inference on the cameras provides a deterrent-based alternative to the more prevalent export-control approaches that screen for products made from the already-dead animals. This newer approach is aimed at preventing the animals' death in the first place.



The TrailGuard AI performs on-camera inference to identify people, animals, and objects.

Earlier versions of the TrailGuard cameras have proven to be effective in the field. In the first 15 months that the cameras were installed on the western border of Serengeti National Park, they assisted in the detection and capture of members from more than 20 gangs of poachers. However, those previous-generation cameras were not 'smart.' They simply sent all images the motion sensor triggered in bulk, resulting in hundreds of "false positive" reports per day when the cameras were tripped by swaying branches or roaming wildebeests. Early prototypes also had a larger form factor and required a connected mini-computer, resulting in a short battery life and higher overall costs.

Early Success at Stopping Poachers in their Tracks

In the first 15 months that prototype TrailGuard cameras were installed in a reserve on the western border of Serengeti National Park, they assisted in the capture of members from more than 20 gangs of poachers.

The TrailGuard AI camera developed by RESOLVE and Intel engineers is designed to address the following key challenges:

- **Data volume:** Reduce the sheer volume of images sent by the camera by using AI to identify people and vehicles only.
- **Battery life:** Conserve battery life by operating at the lowest system power possible and reducing the number of false-positive images or empty images sent.
- **Concealment:** Shrink the footprint of the camera to make it easier to hide in foliage.
- **Cost Savings:** Reduce cost by using a single chip for all the camera's compute functions.
- **Connectivity:** Transmit images in real time in a very remote environment.

The Intel Movidius Myriad 2 VPU proved to be an ideal candidate to address all of these challenges.

Scanning massive numbers of images in real-time and eliminating false positives

Sending pictures is imperative; unlike other sensor options, TrailGuard captures an image, which can be used to confirm the activity of the poachers, how many are in the group, and improve transparency for responding ranger teams. However, the bandwidth requirements to transmit every frame captured by every TrailGuard camera back to park headquarters or to a cloud server for inference are prohibitive. Moreover, it is impractical for rangers to review every image from an array of perhaps hundreds of cameras. Convolutional neural networks (CNNs) running on the Intel Movidius Myriad 2 VPU built into the cameras remove those limitations.

The core AI function of the TrailGuard AI camera is to scan the massive numbers of images captured in real time, discarding the vast majority that have no content of interest and identifying those with humans in the frame. The cameras transmit those images back to park headquarters, where rangers can respond and try to capture poachers before the killing starts.

The use of AI based on CNNs in this solution is a vast improvement over earlier hand-coded approaches to machine vision. Whereas those earlier approaches were inherently limited by the specific instructions provided by the programmer, CNNs are trained using hundreds of thousands of images that show humans in a variety of angles, poses, and contexts so the camera develops "understanding" of what a human looks like. That training gives the smart camera the ability to make extremely sophisticated judgments about the contents of the frame, more closely emulating human sight and dramatically improving accuracy.

Because every image that is transmitted back to headquarters has a high likelihood of identifying poachers, rapid response teams know that every alert means they are likely to go into action, as opposed to receiving a picture of a moving tree branch, a ranging wildebeest, or a marauding honey badger.

The rapid-response teams can engage by staging an ambush, lying in wait at a strategic location where they know the poacher gangs will soon be passing by, or tracking suspects from their last known location at the camera site using a K9 team. Having superior intelligence about where and when to intercept poachers increases the efficiency of these teams, while also helping keep them safe in the field.

Conserving power on the cameras as they patiently lie in wait

The areas where TrailGuard cameras are installed can potentially cover tens of thousands of square kilometers. Visiting every location regularly for maintenance such as changing batteries is impractical. It can also be dangerous, if park personnel encounter poacher gangs unexpectedly, or accidentally reveal camera locations as they disturb the bush around the camera. For that reason, the TrailGuard AI cameras are designed to be rugged, with an estimated battery life of a year and a half versus just a month for previous solutions.

Transmitting just a tiny fraction of the total images captured—only those identified by the neural network as poachers—helps to save power, as does keeping the image sizes small (about 20 KB each). In addition, TrailGuard AI cameras have an even more innovative means of reducing power consumption.

In normal operating mode, the Intel Movidius Myriad 2 VPU is in a protracted zero-power state, and the entire system creates virtually no drain on the battery. A passive sensor detects movement within the camera field of view that potentially signifies the presence of poachers. When movement is sensed, the system silently powers on and captures images; the VPU discerns their contents while operating within a nominal one-watt power envelope.

Complementing that low-power operation, the tiny-but-powerful VPU enables the new generation of smart cameras to be much smaller than previous versions. In particular, the VPU performs not only inference but also controls all of the camera's traditional imaging functions, removing the need for additional bulky hardware.

Maintaining connectivity in a vast and remote place

In addition to covering enormous tracts of land, African wildlife reserves by definition are not intended for human habitation. That reality means that wireless network coverage is patchy or non-existent in the reserves. For that reason, a substantial amount of innovation built into the TrailGuard AI camera system is devoted to communication in these difficult circumstances.

The development team has devised a variety of approaches for connectivity that are evolving over time. The Intel Movidius Myriad 2 VPU provides a rich set of interfaces, which streamlines the process of making changes to the type of connectivity being used. That factor has helped as the team has developed multiple connectivity approaches.

Initially, the cameras sent images using the 3G GSM cellular network, which allows the cameras to be far away from headquarters, but is limited because of network coverage. A hub and spoke architecture where each camera communicates via LoRa to a cigar-box-sized satellite gateway up to 30 km away addressed many of those coverage issues.

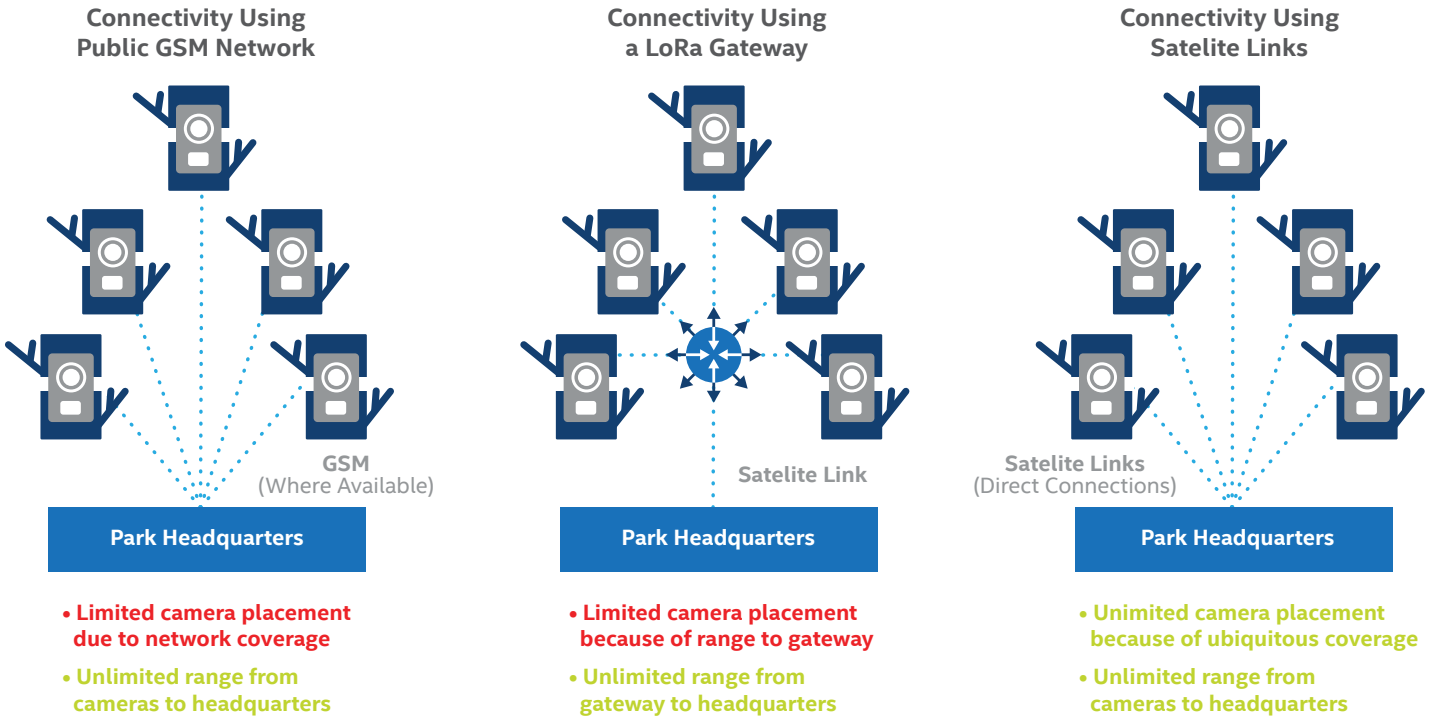
To reduce the complexity of the topology based on LoRa gateways, current work is underway to build satellite connectivity into the camera itself. This approach will take advantage of ubiquitous satellite coverage to provide direct point-to-point connectivity between cameras and park headquarters. The simpler deployment will reduce rangers' potential exposure to poachers, helping preserve the safety of both park rangers and the equipment itself.

Results: Interrupting the ill deeds of poachers

A typical operation detected by the TrailGuard cameras involves a small group of poachers that may place hundreds of brutal snares over a wide area. From the starting point provided by the cameras—and subsequent sightings—a team of responders pursues the poacher gang, aided by tracking dogs. They disable the snares along the way and ultimately reach the gang's camp, where they can potentially arrest the poachers themselves. By strategically placing TrailGuard AI units on known poacher transit routes, it is possible now to protect large areas even with limited personnel. And TrailGuard is easily portable so if poachers shift their routes of entry, seasonally or after arrests along one route, TrailGuards can be relocated and set up at a new locale in a few minutes.

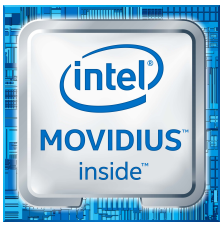
What's more, by changing the deep neural network model running inside the camera, the same hardware can be adapted to entirely different uses. For example, VillageGuard is a planned variant on TrailGuard that will alert villagers or rangers when animals are leaving a park and entering areas where they may come into conflict with humans. RiverGuard, another planned variant, will identify the boats and dugout canoes of unauthorized miners or oil and gas explorers in river-centric regions such as the Amazon.

These and other variations on the TrailGuard camera apply artificial intelligence to protect people, wildlife, and wild spaces. The Intel Movidius Myriad 2 VPU provides the foundation for technological innovation, powering smart cameras tasked with conservation of the natural world.



Learn more about RESOLVE's work at **www.resolv.org/site-BiodiversityWildlifeSolutions/trailguard/**

Learn more about Intel® Movidius™ technology at **ai.intel.com/movidius**



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