Tular Cave Laboratory Observes Rare Amphibian in Megapixel Detail

Arecont Vision Images Enable Research on European Cave Salamander in Dark, Humid Environment

CUSTOMER

The Tular Cave Laboratory in Slovenia (Jamski laboratorij Tular) was established in 1960 by Marko Aljancic, a biologist specializing in subterranean species, who populated the laboratory with the European cave salamander (*Proteus anguinus*). The blind amphibian dwells in the subterranean waters endemic to the Dinaric Karst, where groundwater has carved underground limestone caverns. It spans from East Italy through Slovenia, over coastal Croatia to Herzegovina and part of Bosnia. The highly endangered Proteus can live up to 100 years, is the only European cave vertebrate and, at about 10 to 12 inches long, is by far the largest cave animal in the world. Tular is the biggest cave laboratory in Slovenia and one of the few places where the endangered European cave salamander has been successfully bred outside its natural habitat. The laboratory also maintains a colony of an extremely rare dark-pigmented subspecies endemic to Slovenia. The cave laboratory has studied the ecology and behavior of *Proteus*, primarily its breeding, for more than 50 years. Conditions at the Tular Cave Laboratory include total darkness and near 100 percent humidity. The laboratory maintains 40 Proteus in four large laboratory pools to simulate their natural cave environment, with clay on the bottom and rocks for hiding. Experiments are based on observation and are carefully designed not to harm or stress the animals. The laboratory is a constituent body of Slovenia's Cave Biology Society and is led by Gregor Aljancic.

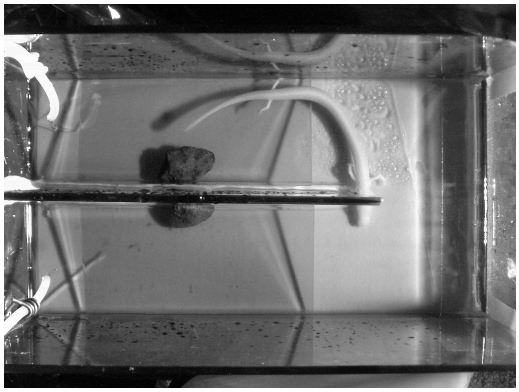
CHALLENGE

A real-time and long-term video monitoring system was needed to observe behavioral experiments and obtain adequate information on Proteus behavior. The system needed to use motion detection to avoid capturing useless video of long periods of Proteus inactivity, and also needed to provide a reasonable balance of video data quantity, quality and required storage capacity. Video cameras needed to capture clear details to provide additional information to help the laboratory design new studies. The system would need to use infrared (IR) light so as not to disturb the animals, who are stressed when their skin senses the visible spectrum of light. Eventually, the system would need to incorporate five to seven cameras that would be permanently mounted and combined into a 24/7 monitoring system accessible over the Internet as the "TularVirtualLab."

MEGAPIXEL SOLUTION

From the fall of 2009 to the spring of 2010, the Tular Cave Laboratory searched the market for a video camera to meet its needs, especially the need for high-resolution images. By far, Arecont Vision's AV5105DN 5 megapixel camera was the only one to fit the criteria at a reasonable price (the few other alternatives were extremely expensive). The laboratory also

preferred a U.S. made product in terms of expected quality and durability in the extreme cave conditions.



Behavioral experiment: Proteus monitored by the Arecont Vision's AV5105DN camera.

Video monitoring of Proteus behavior began with shorter behavioral experiments (up to 30 days), with the system removed from the cave once the experiment was finished. Tular Cave Laboratory uses the Arecont Vision AV5105DN 5 megapixel camera equipped with a 4.5-13mm varifocal IR lens and connected to a computer running Arecont Vision AV100 software as the video management system. The camera is mounted directly above the monitored pool (3 to 6 feet away) or experimental aquarium (1 to 3 feet away). Because of high humidity and dripping water, the camera is enclosed in a plastic waterproof housing. The AV100 software provides video recording based on motion detection triggered by the behavior of Proteus.

Arecont Vision's AV5105DN is a 5 megapixel day/night camera that provides 2,592 x 1,944-pixel images at 9 frames-per-second (fps). Light sensitivity is 0.3 lux at F1.4. The camera uses H.264 (MPEG-4, Part 10) compression to minimize system bandwidth and storage needs. The AV5105DN can also be used at lower megapixel resolutions for various frame rates up to full motion. The camera provides full-motion progressive-scan 1280 x 1024 video at 30fps, 1600 x 1200 video at 24fps or 2048 x 1536 at 15fps. Features include forensic zooming to zero-in and view the details of a recorded image, motion detection and image cropping. The camera's day/night version used at the Tular Cave Laboratory includes a motorized infrared (IR) cut filter for superior low light performance. The camera incorporates Arecont Vision's MegaVideo® image processing at 80 billion operations per second. The AV5105DN can output multiple image formats, allowing the simultaneous viewing of the full-resolution field-of-view and regions of interest for high-definition forensic zooming.

Laboratory pool: 24/7 video monitoring

Other components of the system include a universal power adapter, connection to a PC

using a standard UTP cable, and a PC placed in the laboratory's control room running the AV100 software, serving as a video-image recorder and providing temporary storage. (Wireless transmission was ruled out because it could stress the electroreceptors in the Proteus sensory system). Every two or three days, the data is transferred (via an external hard drive) to a main hard-drive archive installed in a remote location.

Illumination is provided by three or four IR LED illuminators of various intensities to expose the entire area equally. High absorption of IR light in the water requires higher illumination for deeper areas. When observing macroscopic details (such as hatching), the AV5105DN is mounted on the video port of a stereo microscope. Gregor Aljancic designed and installed the system.

The laboratory plans to install the permanent system by the end of 2011, using five to eight cameras with 24/7 monitoring and tied into an Internet connection to the cave. Remote IR video monitoring via the Internet will minimize the potential negative impact on the animals due to factors such as human presence, noise and radiation from the electronic equipment. The change will also relocate the sensitive electronic equipment from the harsh cave environment to a remote location. A wireless access point will be installed at the entrance of the laboratory. From that point, data will pass throughout the lab on a wired network, with a Power-over-Ethernet (PoE) network switch providing power to each camera. After installation of an Internet connection, the server computer – including the PC and high-capacity hard drives to store additional data – will be moved to a remote facility of the Tular Cave Laboratory.

MEGAPIXEL BENEFITS

Higher-resolution megapixel images provide more information and clearer details that were not possible with the poor quality of the previous analog system. The megapixel advantage becomes especially obvious when monitoring a large laboratory pool, which requires the camera to be farther away, with the lens set to a wide angle to cover the entire area. On the video, the animals appear "smaller," but the megapixel camera still provides clear images and allows for digital zooming of moving animals.

Advantages related to video management include the ability to precisely adjust the exposure settings using the AV100 software, an improvement over the analog system's limitation of adjusting only the iris and focus. Forensic zooming, the ability to enlarge a smaller section of a recorded video image and see additional details, is also an important tool both for online and offline viewing.

Viewing videotapes using the previous analog system was time-consuming, and roughly 70 percent of the gathered video showed animals that were not active, representing a huge amount of useless data and a considerable unnecessary cost. Also, it was harder to find events. Since 1998, the laboratory had digitized the video images and used an online video tracking software to analyze the behavior of Proteus. However, digitizing the video further eroded the quality. Also, the system was not efficient in low-light conditions and lacked the necessary detail when observing the whole pool. The use of a megapixel camera minimizes these challenges.

The use of a digital system also reduces the cost of archiving data. Instead of recording on expensive video tapes, the transition to a hard-drive archive provides numerous options to

optimize available storage capacity.

In addition to the direct advantages of megapixel video (image quality, capacity to monitor details, motion detection, etc.), the cameras provide some indirect advantages. Incorporating up-to-date video monitoring technology into the research methodology raises the quality of the research and advances the position of the Tular Cave Laboratory in the scientific community. In addition to providing greater megapixel image quality, the use of remote accessibility will open new possibilities in science and education. To date, the Tular Virtual Lab is believed to have the first 24/7 video system, a tool introduced to the field of subterranean biology that monitors cave life.

During a one month 24/7 monitoring test in January 2011, the Arecont Vision camera mounted above one of the laboratory pools captured a Proteus female laying eggs – an extremely rare event that happens only every 8 to 12 years in captivity

An extremely rare event captured by the Arecont Vision camera: a Proteus female laying eggs

Even in the early stages before the system is fully operative, the value of megapixel imaging as a study tool has become obvious. The data collected by the Arecont Vision infrared cameras has already brought urgently needed international attention to the natural history and conservation of the endangered cave amphibian. Developing additional basic knowledge of Proteus lays the groundwork for a more relevant and effective conservation plan for the endangered species.

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