Stereoscopic Vision Systems

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Improved Robot Vision

Today's robots can perform human tasks during difficult or dangerous operations while the operator is located in a safe place. However, they require very high skills in order to be handled correctly and accurately. Unmanned vehicles and robots have multiple sensors and cameras that give the operator the ability to receive crucial information. Cameras are located in multiple points on the robot but due to their monoscopic nature, they don't have the ability to send the same three-dimensional information our eyes would have captured.

The lack of image accuracy requires the operator to make decisions without complete information during delicate time-stressed operations. Stereoscopic vision will dramatically improve performance during robot operations by lowering the incident time and improving costs and efficiency.
Stereoscopic vision aids the operator in their tasks because it lets the operator view the object under investigation as if they were seeing through the "eyes of the robot." Measurement, simplified camera movement and targeting - using eye tracking - and image preservation are examples of the benefits of this view with true depth perception cues.

"I have been in the forefront of stereoscopic direct imaging systems since 1990, and at Tampa I saw not only direct imaging, but the ability to capture the images seen simultaneously. This was accomplished through the SolidLook system. Additionally the ability to simultaneously authenticate the images has been a major step forward." ~ Ed M. Lazarus

Today's camera position and zoom to catch the visual target is accomplished using a mouse or a joystick, increasing the number of switches and handles the operator has to learn and use. In addition, a robot operates in a rugged and sometimes hostile environment. For these reasons the stereo camera must be stabilized to provide a stable image. The images captured, when classified or reserved, need to be preserved securely and with high confidentiality.

Evidence of integrity and authenticity together with presence in time and confidentiality of the captured images are a post-capture requirement for many customers, agencies and private companies in order to bring the video incident as a proof in court. Looking at the problem from a practical point of view, interfacing stereoscopic cameras and displays with existing robots and transmission systems can be a big challenge. Modular stereoscopic systems need to be fully compliant with existing standards from physical, electrical and software points of view.

Using Stereoscopic vision systems will result in a higher perception of environment depth characteristics, spatial localization and easier, more accurate measurement of volumes and distances. Multiple industry markets will certainly take great advantage of using stereoscopic vision in applications such as:

- Unmanned Aerial-Ground-Underwater Vehicles
- Robot for IED disposal
- Underwater inspections
- Microscopic measurement
- Surgical Operation
- Chip and Pipeline Inspection
- IR, NIR, FLIR Vision
- Forensic Photogrammetry
- Tactical Surveillance Systems / Law Enforcement
- Computer Aided Design
- Hazardous and nuclear materials handling

3-D and Stereoscopy – Critical Differences!

Many people confuse the term "stereoscopic" with "3-D" and for this reason it is very important to underline the correct meaning of each of the terms.

3-D is a computer elaboration, performed by combining different views or multiple images, which will allow the user to see an object in three-dimensions even if the user does not have that

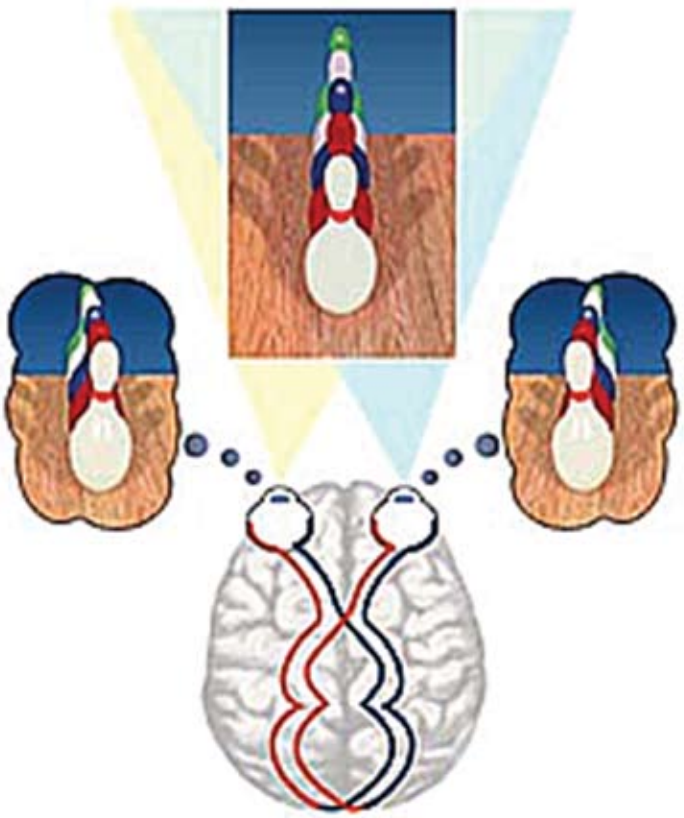

Figure 1. Binocular Disparity

capability (for example seeing only from one eye). Images will be merged and objects will be created according to data that has been inputted. Every user eye sees the same 3-D image that can be created with stable existing techniques.

The computer will do the job of merging the images and showing an object in 3D. There are tools that can transform 2D orthographic drawings into 3D objects, typically used in CAD applications and other methods that transform 2D to 3D images.

The estimated cost for bomb detection and related disposal is approximately $18.00 USD per minute. An incident can last from 30 minutes up to several hours with two hours being the average.

By contrast, stereoscopy is performed by the human brain when two images from slightly different angles are captured by the left and right eye. Just as the stereo sound is not the same for each ear, so the images captured by the eyes are not the same. This is called binocular disparity. Every human being has the capability to see in stereo due to the position of the eyes, while animals that have eyes on the opposite side of their head do not. Stereoscopy is performed by displaying to human eyes the appropriately angled images.

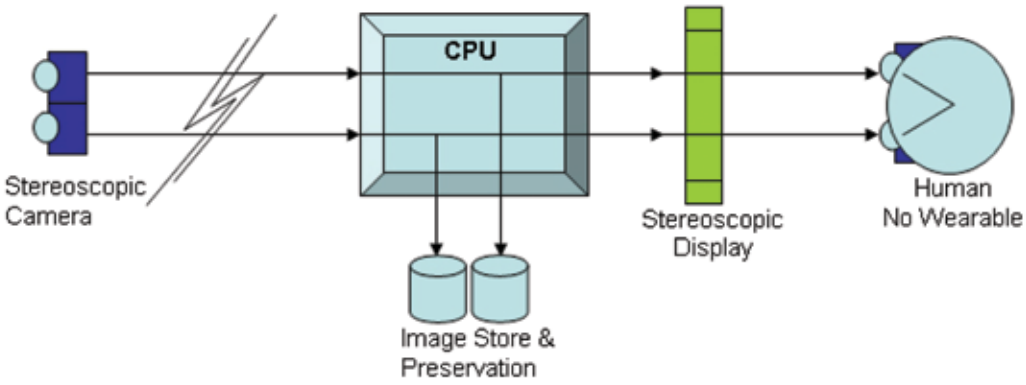

Figure 2. 3D versus Stereoscopy

A Modular Stereoscopic System

To design a modular true stereoscopic system, two images need to be captured by a stereoscopic camera, synchronized, transmitted, securely stored and displayed - one for each eye respectively. A modular system will work with multiple stereoscopic camera types in input (analog or digital) and allow multiple protocols (dual channel, filed sequential, frame sequential, etc.) for outputs. The system will also work with multiple auto-stereoscopic displays (lenticular, barrier, as well with holographic and volumetric monitors) supporting multiple stereo output modes. The system will also accept any storage device to preserve the information that needs to be authenticated, time-stamped and encrypted (for high confidentiality).

It is very important to authenticate the images during the incident time to create legal evidence of what has happened and to have the ability to demonstrate that the images were not tampered with or altered; even unintentionally. The information will certainly flow from the camera through the system that will preserve the images and display them at the same time; but also from the eye/head tracking camera through the system to allow the camera movement, zoom and position (hands free).

There are markets where a stereoscopic solution will certainly bring great advantages, including EOD operations. To test this concept, a new integrated, real-time stereoscopic system, including a holographic auto-stereoscopic monitor (no glasses required), camera movement and position with eye tracking (non wearable) and secure image preservation was created. The solution was tested against a monoscopic system to understand the real advantages in terms of time, security, ability to perform and expense while executing intricate procedures for EOD suppression and disarmament.

Participating companies responsible for creating this system included ANDXOR Corporation, L-3 Communications Display

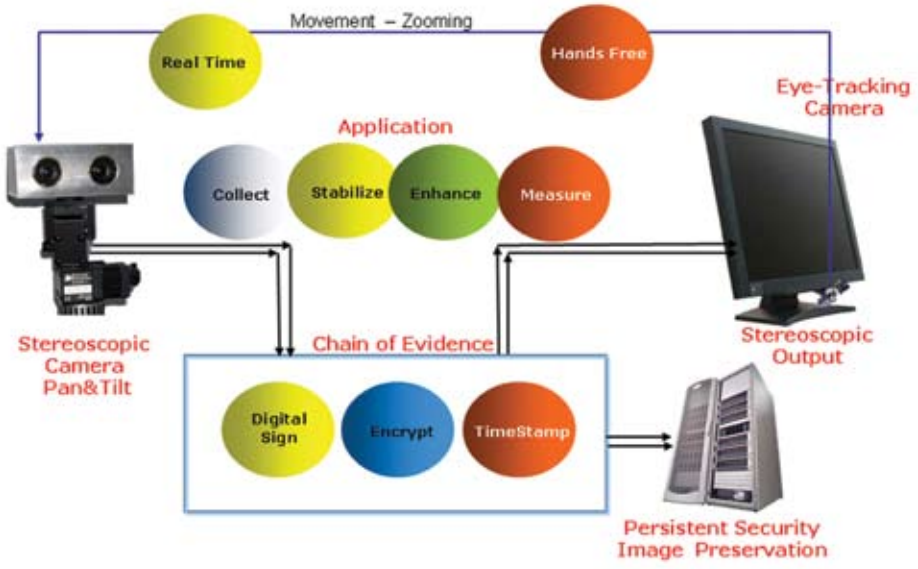

Figure 3. Modular Stereoscopic System

Systems, LC Technologies, Bristlecone Technologies, and 3D Advanced Technologies. The demonstration system was installed on a Remotec Andros Robot creating a virtual incident environment during the 2006 IABTI Conference in Tampa.

More than ninety robot operators tested the system during the conference. User comments regarding vision accuracy, brightness, as well as system learning and decision time while controlling the robot were very positive. The operators did not need additional cues like sizes of known objects, lighting, shadows and other details to figure out the distance or position of the robot arm with respect to the object under investigation. They can actually see - in real time - field depth and related distances to move the robot more quickly and with higher precision. Further enhancing the ease of use, the eye tracking capability allowed the operators to move the camera without using their hands, as if the operator's eyes were located on the robot itself.

The stereoscopic vision system presented at IABTI was called HoloTracker and incorporated the "Solid-Look" (www.solid-look.com) stereoscopic modular image processing system provided by ANDXOR, the StereOpsis camera provided by Bristlecone and the holographic display provided by L-3. Solid-Look gives the viewer an extension of their own vision and enables them to see in real time as if their eyes were at the point of the cameras and also stores and preserves securely all the images using almost any type of camera and display.

The HoloTracker with Solid-Look demo shows several advantages for operators:
- high definition stereoscopic images in real-time without the need of any special eyewear; camera movement and zooms "hand-free" thanks to the eye-tracking technology;
- records the stereoscopic images in synchronized files (left and right);
- authenticates (digital signature), encrypts and timestamps all the images and stores them safely providing legal evidence of authenticity, presence in time and confidentiality;
- provides internal storage of more than three days of continuous operation;
- plays back the stereoscopic images from a specific frame for complete video review.

HoloTracker with Solid-Look is a modular system that can be used in multiple industries from military to homeland security to pharmaceuticals including research, forensic and underwater inspections.

About the Author

Raffaello is the President of ANDXOR Corporation, New York. He has more than twenty years experience in IT application security and has designed and managed almost all of the solutions delivered by ANDXOR. He is in charge of US, Australia and Far East Solid-Look market development.

Figure 4. Solid-Look on Remotec Andros

"By comparison to conventional 2-dimensional video, the stereoscopic system significantly improved my ability to operate the robot. When handling objects with my own hands, I need the 3-D perception I get from 2-eyed vision. Stereo vision feels even more essential when handling something remotely with a robot manipulator." ~ Dixon Cleveland