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Seeing is Believing

Video feedback that closes the forgotten loop of human activity in automated plant systems makes it possible to reconstruct events for diagnostics, operator training and process improvement, says *Stephen Rubin*.

Over the past decade we've spent, as an industry, billions of dollars and millions of man-hours automating our factories and plants. The solutions have included adding sensors, networks and software that can measure, analyze and either act or recommend action to help production get to "Six Sigma" efficiency. However, few, if any, plants are totally automated.

Despite a continuing effort to remove personnel costs and drive repeatability through automation, all plants and factories have human operators. These important human assets are responsible for monitoring the control systems, either to act on system recommendations, or override automated actions if circumstances warrant.

Most of the time, operators let the system do what it was designed and programmed to do. Sometimes, operators make errors of commission, with causes ranging from misinterpretation of data to poor training or errors of omission attributed to lack of attention or speedy response. An operator's job has often been described as hours of boredom interrupted by moments of sheer panic. What the operator does during panic situations often depends on how well he or she has been trained, or "tuned."

The focus on reducing human error isn't trivial: multiple studies by the Department of Energy (DOE) and Electric Power Research Institute (EPRI) have identified the probability of errors in power plants and nuclear facilities. System availability, quality of output and operator safety will become even more important as industry restructuring (such as the Smart Grid initiative) takes hold. We can expect similar issues across the broad spectrum of other manufacturing and process industries.

We know from life experience (and management training) that "a chain is strong as its weakest link". The irony in our factory automation strategy is that while we've invested heavily to improve our data sensing and automation systems, we haven't made similar investments to strengthen and improve the human element (the operators) in our systems.

Diagnosing problems

There are instances where time is wasted just figuring out "what happened" before remedial action is taken. Often, the plant is down while troubleshooting occurs, or the problem can't be determined until the engineers are allowed in to do the troubleshooting. In the meantime, the plant must operate at reduced output or quality.

While we can view the conditions that occurred during an incident with process historians, we don't really know what the operator response was. For example, years ago I was doing a plant start-up involving a new distributed control system at a cement plant. We received a call saying some "ductwork had collapsed" and the control system was suspected as the culprit.

After arriving at the plant, we spent a full day poring over alarm printouts and talking with operators, even decoding register stacks in the software – looking for the problem (the "ductwork" was a 15-foot diameter 30-foot long steel duct connecting the preheat tower with the kiln). Ultimately, we discovered that the induced draft fan damper's hydraulics were connected backward (when the operator commanded "open," the damper closed and thus the duct collapsed like a plugged drinking straw).

Had we only had a video recording of the operator's console's display, we could have seen the command, the damper position indicator and the vacuum

In this oil spill, the operator was not notified until the floor in the pumping station was inches deep in fuel oil, and the leak detector finally went off. Observing the video absolved the operator, because it became obvious that the leak detector was in the wrong place.

measurement. It would have saved man-hours of engineering time, and would have had the plant up and running many hours sooner!

Another example involves an oil leak at a pumping station. While the remote video camera recorded fuel oil spilling onto the floor, the leak detector didn't go off until the floor was flooded. When it did, the operator quickly switched to the video feed, saw the leak, and called in a cleanup crew.

If a console recorder had been installed, it would have helped diagnose the problem immediately – that is, the leak detector was in the wrong place. By putting remote video on one screen and the operator console video on another screen, engineers could have seen exactly what conditions existed in the pump house when the operator was finally alerted.

A console recorder can clear an operator of possible errors. In the case of the oil spill, it would show that the operator did exactly what was necessary given the information available at the time. If regulations require an operator to perform certain functions at certain times or after certain activities, the console recorder can document that the procedures were done properly. It would give operators confidence to know that they are being "backed up" by the console recorder.

Also consider the classic experience of an engineer getting the phone call in the middle of the night saying that something isn't working right. After arriving in the control room, the first series of questions is, "What happened, what did you do, and did you change anything?" The answers to the last two questions are often "nothing" and "no." A video playback of the display might corroborate the answers, or it might shed light on things forgotten.

Possible approaches

Until now, the use of operator console playback to support better operations has been extremely limited. A few systems allow the playback of historically archived data through the human machine interface (HMI) display. This technique is cumbersome because it requires the historical archive to have collected all necessary data prior to playback. This method re-creates the display at the sample interval of the historian, not necessarily at the frequency of the display, thus raising the possibility of aliasing display data. Worse yet, it doesn't answer the question, "What was the operator actually looking at when the event occurred?"

Another method involves putting a video camera over the shoulder of an operator to record the screen. Unfortunately, the video camera typically does not have enough resolution to see everything on the screen and, if the operator has multiple screens, it requires a video cam on each screen. Also, there is no way to coordinate this video with other plant systems, such as the historian and video from the plant floor. In some venues, work rules discourage the use of cameras in the control room.

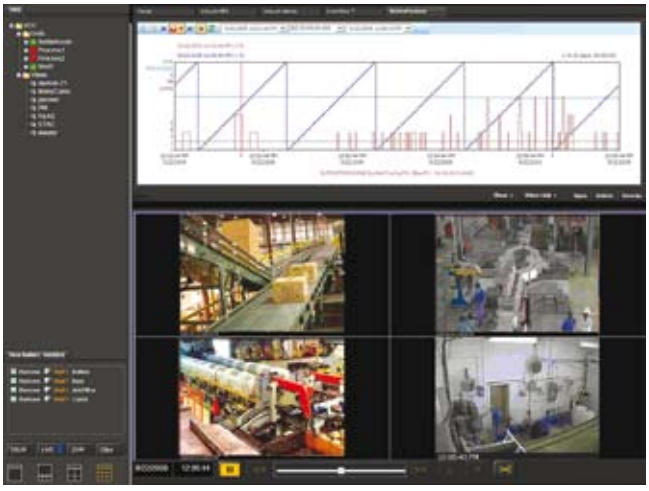
The ideal solution is a system that can coordinate what the operator actually saw, video from the plant area where a situation occurred, and data from an historian. Such a system can recreate the exact conditions that occurred during an incident.

For example, "alarm floods" are an ongoing problem. Studies show that 90 percent of alarms are due to incorrect system configuration and poor alarm strategies. Alarm floods usually occur at the worst possible time for a control room operator, such as start-up, shutdown and trips. Eliminating alarm floods requires a complete analysis of alarm priorities. This would be much easier if the analysts could see what the operator was presented with during an alarm flood.

Software snapshots

With the advent of inexpensive computers, digital video recording and specialized software, there are new ways to improve operator training to reduce errors and improve uptime and quality. Console recorder software can be loaded as a small module into the computer running the HMI or DCS/SCADA console display software. This "software camera" takes the image generated by all programs using the computer's display (including HMI software) and presents it to a video engine where it is recorded as a digital video stream. The result is a video file identical to that which would be recorded by a real camera but, in this case, contains the image of the HMI display, as well as the mouse movements as the operator moves and clicks around on the screen.

Because there is recording of exactly what is being shown on the operator's display, there is no ambiguity about what the operator



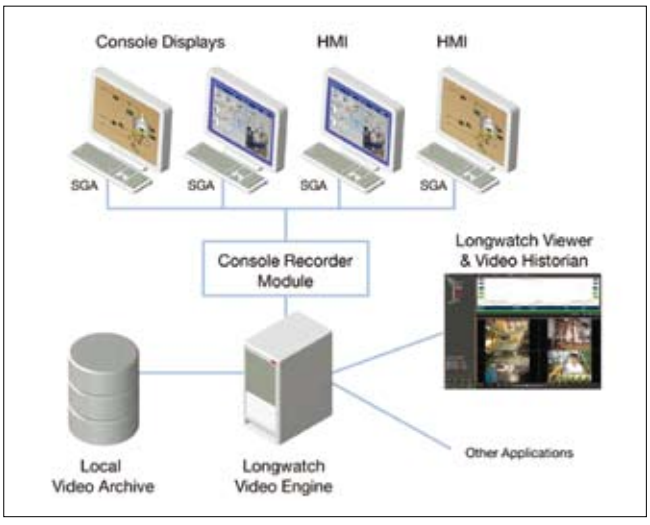
Video and historian tools allow engineers and operators to go back in time to view what happened and to see what actions were taken at the HMI during a plant incident.

is seeing. Thus, ex-post-facto analysis of the display might offer insight as to whether the sensed data (measurements and statuses) were displayed properly, and whether the operator took appropriate action. The console recorder video will also show if the operator was looking at the appropriate display or was otherwise distracted.

The use of a video historian expands the analysis capability further – to enable the user to see exactly what was being displayed on a variety of recorded consoles when particular events occurred. Many plants use multiple HMI displays – typically the "three CRT" configuration pioneered by DCSs years ago. Multiple HMIs can display events and data ranging from plant alarms to messages generated by other applications (such as workflow tracking or quality/lab testing subsystems). Being able to see what was on all the displays at the time of an event can be very useful for reinforcing good manufacturing and safety practices, and for training the operators which screens to watch under various conditions.

Recording the console displays is feasible due to the advances in networking and video management technology. The foundation of the system is digital video recorders, called Longwatch Video Engines (LVEs). These collect video from the consoles or real cameras, archive the video in distributed data stores, and monitor for real-time events that indicate areas of interest in the video.

Each HMI or DCS workstation is connected to Longwatch Video Engines using a screen grabber applet (SGA). The SGA takes a copy of the screen image of the HMI console (including mouse movements), compresses it and sends it over the network to the LVE, where it is processed and recorded. Video from the operator consoles can be combined with historian data and video from plant cameras to reconstruct an event.



A screen grabber applet (SGA) takes a copy of the screen image of the operator console (including mouse movements), compresses it and sends it over the network to the video engine, where it is processed and recorded.

Enhancing training

Flight data recorders and cockpit voice recorders have become standard equipment in airliners. They have had a material effect in helping reconstruct accident scenarios and, in doing so, offer real information for improvements in airplane and airport design, flight control systems, and pilot/crew training. As a result, the safety and efficiency of air travel has improved to the point where it is safer than and cost-competitive with automobile travel.

The same opportunities exist in the operations of our plants. Large, complex facilities like nuclear power plants have simulators to help train operators. But with operator console recording, every plant, regardless of size or complexity, can collect real information about operations and operator actions – so that improvement in operations, design and training can be achieved. Console recording could also be combined with simulator training, so the instructor can play back what the operator did during a simulation and critique the operator's actions.

Every plant has one or more excellent operators that always know what to do in every situation. With console recording, it's possible to analyze an expert operator's response to various process conditions, and use it to train new operators.

Screen design

System integrators (and plant engineers) often put together HMI displays based on their own designs and experience. For example, many HMI displays use high resolution graphics, 3D icons, flashing colors and other modern techniques to display information. But do operators actually use these displays? Or are they only used when VIPs are touring the control room or an engineer is watching?

Analysis of operator actions might reveal that operators actually prefer a simple faceplate display to exotic graphics and, as soon as the design engineers leave the control room, they switch over to the tried-and-true displays. If so, then the display engineers should concentrate on improving those displays instead of developing "VIP displays".

With console recording, the engineer can zero in on particular operations, alarms and events and see what was displayed and how the operator reacted. In this learning environment, the designer can quickly determine if the man-machine interface display and command sequence is clear and unambiguous.

In the spirit of kaizen, or continuous improvement, the engineer can use these console recordings to refine the data display and command entry techniques. Better yet, the recordings can show the designer what happened during unusual events: things that would be difficult to observe unless you were living in the control room, but easy to observe because the "game highlights" have been captured. Integrators who use console recorders to demonstrate their commitment to continuous improvement can develop a competitive advantage and additional value for their clients.

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Closing the loop

In our global economy, competition is broad, consumer demands are high, and margins (for error and for profit) are razor-thin. As part of cost reduction and increased automation, fewer humans are involved with operating larger and larger plants. Thus, those few operators who are left have huge responsibilities, and their actions can have a major effect on plant output and, ultimately, business performance. Just as the new global economy has demanded new ways of operating business, it demands new ways of making sure operations deliver efficiency, quality, flexibility and availability.

State-of-the-art manufacturers in process and discrete industries have invested in advanced control software, manufacturing execution software and modeling software to "tune" everything from control loops to supply chains, thus driving higher quality and productivity. The purpose of tuning loops is to reduce errors and thus provide more efficient operation that returns quickly to steady-state efficiency after upsets, errors or changes in load.

The "forgotten loop" has been the operator, who is typically trained to "average" parameters to run adequately under most steady-state conditions. Advanced tuning of the operator could yield even better outputs, with higher quality, fewer errors and a wider response to fluctuating operating conditions.

Video feedback is a simple yet effective technology that closes the forgotten loop of human activity in the automation system. Cost-effective and direct video recording and playback of the operator's display and action can help manufacturers become more competitive, while providing a means to support operations quality and repeatability through analysis and training. **CEA**

Stephen Rubin is President & CEO, Longwatch (www.longwatch.com).