Improving Field Operations and Safety with Wearable Technology

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SUMMARY

Utility field professions such as linemen, inspectors, and construction workers are experiencing large amounts of change from retirement. This change is also known as the knowledge gap. Operations departments are looking towards technology to help bridge this gap and improve the safety, efficiency, and effectiveness of their personnel. Wearable technologies integrated into digital twin systems are one answer to this gap. This paper will dive deep into one portion of the digital twin technology, geographical information systems, (GIS) and how integrated wearable technologies can address pain points from the knowledge gap. Examples from past and current uses of the technologies will be provide, as well as, future use cases for forward thinking.

KEYWORDS

Digital Twin
Wearable Technology
Knowledge Gap

Utility Industry Knowledge Gap

Many utilities are facing a common problem. With many experienced individuals with our industry's knowledge approach retirement, the departure of mission critical workers such as linemen, technicians, plant and controls operators and engineers creates a critical knowledge gap.

Though utilities are not the only industry facing this problem, it is hard to imagine a more critical challenge for an industry that is so vital to the global economy. According to the Edison Electric Institute (EEI), retirements of these mission critical workers has been hovering around 10% annually, on average. This is partly due to the early retirement incentive packages provided by many North American utilities. As a result, many utilities today may have only one person with the tribal knowledge and understanding of how systems actually work.

Though this rate of turnover is expected to slow over the next 10 years to more normal levels in the range of 2-3%, it still doesn't alleviate the problem of educating and training a less experienced workforce quickly up to speed. It goes without saying that these workers will require many years before they reach the level of experience and knowledge achieved by those retiring.

Operations departments are looking toward technology as one solution to help bridge this gap while maintaining and even improving on historical levels of safety, efficiency and effectiveness. One solution for this knowledge gap are wearable devices integrated into a digital twin.

This paper will dive deep into one portion of the digital twin technology, geographical information systems, (GIS), and how integrated wearable technologies can address pain points from the knowledge gap.

Digital Twin Concept

Wearable technology has a relationship with the emerging field of augmented reality, but this particular application lives in the space between geographical information systems (GIS) and building information management (BIM) systems. A digital twin is an integration of GIS and BIM data, which is defined for our purposes as a digital representation of an actual physical asset.

This technology draws on key elements of both GIS and BIM systems but fits most appropriately within the GIS universe (see Figure 1). We are defining this digital twin application within the parameters of the Autodesk - ESRI vision paper on the GIS/BIM cycle:
https://www.esri.com/~/media/Images/Content/landing-pages/autodesk/Esri-ADSK-Vision-Paper

For utilities, the illustration of the intersection of GIS and BIM platforms is not only a definition for digital twins, but a high-level roadmap for transitioning to a digital company. Many utilities already implement some form of GIS technology which can be integrated into a digital twin cycle.

To coin a new phrase, it might be most appropriate to call these new wearable devices "assisted reality," because they are truly blazing a trail toward a new industry norm.

Paper Versus Digital Media

Until now, data collection in the field has primarily relied on the pen and paper method with notes taken in the field transcribed into a GIS system when the user returns to the office.

Recently, GIS technology providers have allowed utilities to collect field data with cell phone or tablet applications, which has reduced the need to transcribe notes once the inspector returns to the office.

Now, with the introduction of wearables, all-new possibilities are opening for field data collection.

The VisualSpection system developed by Manitoba Hydro International (MHI) and Burns & McDonnell is a 100% voice-activated software which runs on head mounted tablets. These head mounted tablets clips directly into a standard construction hardhat. As a hands-free technology, it allows real-time video communications between the field inspector and teams of experts who may be located remotely at a number of locations.

This leverages the time and availability of subject matter experts within a utility. With no need to spend the majority of their workweek driving hundreds of miles between sites, these subject matter experts are far more available to answer questions and provide immediate feedback, no matter the situation.

In most field data collection situations, wearables are clearly proving to be a more efficient and effective data collection method. Verbally recording a note, coupled with speech to text translation, is much faster than typing a note.

Safety Impacts

All utilities have a goal of zero workplace injury incidences; this technology can be a big step forward in achieving that goal.

By simply eliminating the need to constantly look down when taking field notes via traditional pen and paper or on cell phones or tablets, the user with a wearable headset never takes their eyes off the task at hand. With their hands free and unencumbered from distractions, the field inspector will be much safer when walking around a site.

When the worker needs to document or view information, they can quickly glance in their peripheral vision at the wearable's screen.

Eliminating distractions via wearables is somewhat akin to eliminating the dangerous practice of texting while driving. The chances of slips, trips or falls, are greatly reduced.

A second safety factor worth mentioning is the greatly reduced risk of injuries or fatalities during vehicular accidents. For companies with widely dispersed field staff and project locations, vehicle safety often ranks at the highest risk factor. With only one person traveling to job sites, versus three, four or five, the safety implications are obvious.

The value of wearable technology becomes even more pronounced during the current COVID pandemic. With the ability to send a single inspector with a wearable to field locations or project sites, the risk of exposures to the virus are greatly diminished for both field staff and the review team.

Capturing Information More Efficiently

The potential to greatly decrease operations and maintenance (O&M) costs is emerging as one of the most compelling features of wearables technology. Because of the ability to video call back to an office, technical center or other remote location, the field inspector can often get immediate resolution to an issue identified in the field. By sending a single individual to a field location or project site rather than a team, the savings and efficiencies can be tremendous.

In addition to O&M cost savings and improved safety, wearable technology enables seamless integration with GIS platforms by allowing the data gathered by the user to upload it instantly. As seen in Figure 1, a user looking directly at an asset generates a digital marker. In this example of a digital image of a transformer, the GPS coordinates are uploaded as well as all documents with work orders or other notes within the system.

Figure 1

The data also can be integrated into a variety of asset management systems, which is often a weakness in data stewardship among many utilities. Every utility wants and can benefit from all data being hosted in 1 central location, but the reality is that most utilities are segmented and siloed with systems that do not “talk to each” other due to differing protocols and standards for how information is collected and maintained. With wearable technology, there is an opportunity to reevaluate existing siloed databases and create common standards for how information is collected and dispersed. We can collect much richer data and integrate it with systems that communicate with each other through secure REST API’s. With this wealth of data collected on site and then uploaded to the cloud, it can be available on many different asset management systems.

Capturing Knowledge

Every interaction between a field inspection and remote review team can be recorded and tagged to an asset in a digital twin system. In future work, employees can view the recorded video call to refresh their memory on a process before starting the work.

When tagged to a digital twin system, recorded asset work orders can be analyzed to determine if certain assets and work processes are causing confusion based on the number of video calls that occur. The higher numbers of video calls for a particular asset or process indicates a larger number of questions that field personnel are experiencing.

In past utility pilots, wearables integrated into a GIS have shown massive returns on investments for field data collection.

In the future, Mixed Reality (MR) glasses can take this technology even further. MR glasses and headsets are an advanced, more interactive version of Augmented Reality (AR) glasses that are primarily used today. MR glasses can offer binocular displays (i.e. information displayed to both eyes) while allowing the user to see the current environment. The term “mixed” is used because the technology enables a blend of assisted and virtual reality. Some of these advanced MR smart glasses can allow full 3D models to be viewed in the field.

Use Cases Illustrate Value

Manitoba Hydro Telecom

Manitoba Hydro Telecom (MHT), a business unit of MHI, is Manitoba's local data services provider, which mission is to commercialize all the telecommunications infrastructure throughout the province. A lot of time is spent traveling to remote locations staking out new lines, particularly in northern regions of Manitoba. As may be expected, this often creates travel issues due to a colder climate and long distances between population centers and often a junior person would be sent out.

Traditionally, these efforts were done with paper and pen for field notes after a physical stake was driven into the ground and a few photographs taken with a cell phone. The photos and scanned notes generally were uploaded to a shared public drive where they just sat.

With integrating wearable technology, MHT first piloted the technology by sending junior field crew instead of new fibre engineers to the northern zones. Every time a stake is placed, the physical location is digitally marked creating a known GPS location with a time stamp.

As soon as the field person can get to an office or a hot spot, all the data sitting on the device is uploaded to the cloud. The device works very well, even in remote regions of northern Manitoba so MHT also has the option of live streaming if needed while the field person is on site and communicating with the office staff so an actual site depiction is recorded.

This provides a great deal of value to guard against unforeseen events. As might be expected with the harsh environment of northern Manitoba, stakes will sometimes get covered or get hit by snowmobiles. Where in the past, the stake would be lost and require another visit from the field staff, now there is a digital record of the stake location, even if it disappears. With the digital point that is captured, it becomes a digital twin just like any other asset we inspect and digitally capture for uploading into our GIS database. MHT can track the men and women through a GPS tracker, so when weather conditions that are deteriorating, MHT can warn the field personnel to get to the nearest community for shelter and wait out the weather.

Honduras

Utilities in Central America are like utilities everywhere else with most of their assets on the distribution network. With a number of distribution system poles to inspect, typically this utility would send out three staff with one writing down field notes and the other two looking for basic failures or pending failures like damaged insulators. One would be holding a tablet writing and retrieving basic information on the asset while another might be taking photos.

This utility, which is not being named out of confidentiality requirements, adopted a wearables system for these inspections of tens of thousands of assets within the distribution system. Needless to say, it has sped up the process exponentially.

This case illustrates another important feature of wearables technology which is that a transcription of voice input into the device is automatically generated and recorded. The software also has the ability to translate up to 90 languages. With these inspection notes being verbally recorded in Spanish, the transcription was available in the native language of this utility’s supervisory personnel.

This illustrates the great ease of employee onboarding, with language no longer a barrier. Everybody globally now uses universally familiar tablet technology. With this application being voice driven, it is even more user friendly.

In addition to walking from asset to asset, the single inspector now has a guided workflow document that directs them to the asset that needs to be inspected and specific features that need to be looked at on a standardized basis.

This technology has huge implications for construction crews as well as utilities. With many field-crews still using pen and paper, wearable technology eliminates the problem of field notes getting lost or the difficulty of reading often-illegible handwriting. Many construction crews don't enjoy the burden of carrying around a hand-held tablet so with the technology mounted to a hardhat it can help alleviate that issue.

This isn't just about cost savings created by the need for fewer people. With field staff not spending as much time inspecting and documenting findings, they now have more time to perform the actual maintenance and other work they should be doing. They have more time to fix any damaged assets they encounter.

Caribbean Utility

Utilities in the Caribbean are constantly preparing for hurricanes and tropical storms that can damage assets. This utility, which also is not disclosed due to confidentiality arrangements, is now using wearable technology to prepare for this year's hurricane season.

By inspecting and digitally logging the GPS coordinates of all assets, this Caribbean Utility is much better prepared when an extreme weather event roars ashore and wipes out a significant number of assets.

The digital record also reduces risk in a post-storm scenario as it reduces the need to send as many people out to dangerous places. By sending a single staffer out with a wearable, they can live stream the damage back to a control center and create a log of where damaged assets are located in a fraction of the time as before.

With the damage, destruction, and chaos that is typical in the aftermath of a hurricane, digital records eliminate confusion over where a pole or tower might have been located. This utility was already switching over from paper to a tablet-based system though this was still far from optimal as field crews still had to type notes and record data. They often had difficulty from glare on the handheld tablet's screen surface. They alleviated this pain by adding in a wearable device to input the data quicker and safer; using the table for Google Mapping referencing. So whether it was paper and pen or a handheld device, a wearable device has given them a better system by using a headset to record all the relevant data on all assets. Now with data being sent to ARC-GIS, it is automatically updated instead of physically being written on a tablet.

Midwest Nuclear Utility

In this use case, wearable technology has streamlined several workflow issues stemming from labor agreements at this undisclosed Midwestern utility with nuclear generating assets. Essentially, plant inspectors would enter a containment area and then if they noted an issue that needed to be resolved, they would have to exit the containment environment multiple times to document findings, all requiring multiple decontaminations of clothing and equipment.

Wearables paired with live streaming, skilled work crews enter the containment vessel and communicate with an expert who can guide them through a workaround. This resolves the issue without the need to exit and enter the containment environment multiple times.

Northeastern Utility

With a service territory that contains dense tree cover, this undisclosed northeastern utility faces a number of issues with vegetation management. Traditionally, the program was managed with inspectors relying on the paper and pen method to record the few trees that posed a danger of falling onto lines.

Later, when the utility moved toward digital technology to mark trees based on GPS coordinates, it still faced problems due to the dense cover which often made it difficult for trimming crews to locate the exact tree that had been marked for removal. In those cases, the crews would typically take out all the trees in each area, which created environmental concerns for some customers.

Since adopting a wearable system, the utility inspectors travel along transmission and distribution corridors digitally tagging trees with precise locations. The tagged tree are shown with an augmented reality marker. This resolves several issues the utility previously faced. If the tree trimming crew faces a question over whether a tree has been marked, they simply put on the wearable device, turn their head and can quickly see the digital record of the actual tree that was marked for removal.

Burns & McDonnell Project Management

Since first testing wearables beginning in August 2017, Burns & McDonnell has now deployed the technology across all divisions. Prior to the COVID pandemic, the goals of utilization were primarily to reduce travel costs and enable better data collection. Now, as the entire industry copes with the pandemic, the benefits are even more pronounced.

The company has long utilized a variety of GIS technologies and now, with wearable hands-free devices, it is safer, faster and more efficient to gather this data. Since our engineers and construction site managers are often out in the field with a set of drawings in one hand, a tape measure in the other and a cell phone or tablet in a backpack, it goes without saying a certain amount of juggling is required while walking the job site.

With wearables, their hands are freed, creating a safety benefit as well as the efficiency of live video streaming with a team of engineers, constructors, permitting specialists and other professionals back in their offices. With wearables, we now send two people to a site, versus the five or more that were previously required for project scoping.

The advantages have become huge, as thousands of Burns & McDonnell engineers and construction employees use wearables, particularly now, when COVID prevents extensive travel to many job sites.

When on a scoping assignment, we just video call the entire project team. A local person drives to the site fitted with a wearable device, avoiding the need to send multiple people via airplane and rental cars to the site. This has had a tremendous impact on business and operations costs and we’re helping clients do the same. By providing clients access to video calls, they can provide direct input during the project scoping process, where in the past they may not have been able to, per company policy during COVID.

An additional benefit is the involvement of specialized knowledge experts throughout our nationwide network of offices. Even before the pandemic, these experts often did not have the time available to travel to project locations. As questions emerged on complex technical specifications, the only alternative was to obtain answers via email, which was not optimal for the extensive analysis needed to answer many questions.

Now, when we need one of our transformer experts, for example, we can add them to a site-specific video call to enable them to actually view the situation on the ground and talk it through with people in the field. The result is always a better and faster answer.

This process has enabled us to reduce requests for information (RFIs) and when we do get one, the answers are greatly expedited. Instead of doing eight or more hours or research, often based on limited or sub-optimal photos, the live video feed can enable our experts to view the situation and do one of two things: 1) pull up a standardized work order form available via the device and fill out the data fields while on the call, or; 2) create a custom work order form developed specifically based on feedback from the field inspector. With the expert developing the work order procedure based on actual field conditions, with step-by-step guidance for what needs to be done in sequence, the accuracy and efficiency of results are improved immeasurably.

As the field inspectors completes the workflow it is entered digitally into the system where it is immediately available to all team members for review and correction if needed. The visualization aspect of the technology is a key element as the user is able to see color-coded markers in the digital twin that indicates assets that are marked with a specific action item that must be addressed. The type of asset is immaterial. It can be anything from a transformer, to relay panel to battery bank or circuit breaker.

Once data is entered into the system it is encrypted and secured, per utility requirements, so it can only be viewed by project team members and authorized personnel with the utility client.

The sessions are also recorded, making them available for future training videos where instructors can easily point out steps that were missed or could have been done differently.

Future Wearables Applications

Since the introduction of Google Glass, wearable devices have found their footing among many sectors and the application for utilities has been one of several that are growing rapidly. As these wearable devices continue to prove out their value, future use cases will continue to emerge. Some of these could include:

Geofencing to Implement Safety Zones

The current generation of wearables may someday be replaced with much smarter ones. Rather than simply protect the wearer’s eyes, these wearables will feed workers real-time information designed to protect them against potential jobsite dangers. This adds a whole new dimension to safety.

Using Bluetooth beacons or GPS software, it is possible to build geofences that define a virtual geographic boundary. Transmitters then enable wearables and other devices to perform specific actions when in proximity to them. Most of us are likely to have already experienced a geofence as we have walked into homes or offices where the lights turn on or off as you enter or leave an area. On a construction site, geofencing can play an important safety role. If employees lacking the required safety clearance cross into a restricted area, for example, they can be alerted via a notification displayed on their wearable. The geofencing software can be programmed to map a safe exit route.

Should employees remain in or progress further into restricted areas, the technology can alert the project safety manager about the breach, identifying the offending workers and their current location.

Site Emergency Notifications

When an emergency occurs at a jobsite, best practices typically call for crew members to report to a defined place for a headcount. This process can be especially challenging on projects with hundreds of active workers dispersed over a large footprint. Some may need to navigate multiple safety hazards on the way to the nearest gathering point.

Safety-enabled wearables, however, can alleviate many risks. These devices can enable a safety manager to send a mass emergency notification to each crew member's wearable. The devices would take it from there, identifying each crew member's precise location and all the pre-programmed safety hazards in the vicinity. The wearable can then direct the worker along a safe route to the nearest gathering location.

Additional environmental applications can apply as well, such as identification of historical sites or wetlands. A headcount itself could be completed instantly using the GPS data from each wearable. Missing personnel could be tracked using the same GPS data, which emergency responders could use to locate and rescue them. Applications like these will be most valuable if an entire crew is outfitted with wearables. These "lower-end" wearables currently cost about $500 or more each, a significant investment. But prices are trending downward, and it is very possible these wearables may one day soon be as ubiquitous as hard hats on major construction sites.

Summary and Conclusion

We are entering an exciting new phase of future technology applications that will result in a number of operational benefits for utilities around the world.

For example, in the future we will see full 3-dimensional models where the user will be able to click on some element of the digital representation of an asset and see a wealth of data immediately available. Say the user wants to see a fan, for example. All he or she has to do is click on the digital image and all relevant specifications will be immediately available. The implications for keep accurate asset inventories, among other things, are quite obvious.

As the utility industry prepares for the future it is prudent to take measured steps toward the goal of more advanced use cases. This is an important concept for our industry to bear in mind. The theory of future applications is certainly exciting but the reality is we must take small steps — baby steps if you will — toward our goals, proving out each use case in a logical and sequential manner as we fully develop the potential of wearable assisted reality technology.

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