Augmented Reality

**Abstract - AR is an interactive experience in which digital information is superimposed on a real-world environment via a phone, tablet, or wearable device. AR allows users to superimpose digital visuals in real-world environments, giving the impression that the digital item is physically present in the user's field of vision. With the use of a smart phone or wearable device, a picture, item, or full facility may be activated in AR. With augmented reality, you may carry a cargo vessel in your pocket, get instructions to the nearest muster site in an emergency, and deliver real-time information throughout a factory assembly process. It’s still early days for augmented reality. Augmented Reality is the next technological advancement that will actually transform people's lives (AR). According to IDC, global investment on Augmented Reality (AR) and Virtual Reality (VR) would exceed $ 160 billion by 2023.**

**Keyword –** Augmented Reality, Markless AR, Marker - Based AR, Projection – Based AR, Superimposition – Based AR

***What is Augmented Reality?***

The technology that superimposes an image over a user's perspective of the actual world and enhances it with sound, touch, and even smell is known as augmented reality (AR). It is a hybrid of the user's real-world environment with a computer-generated virtual environment. AR is a technology that will blur the barriers between reality and fiction.

Augmented reality has spread beyond games and headgear to a variety of businesses. In general, Augmented Reality is being more widely used for tasks such as assembly, maintenance, and repair, as well as teaching, training, retail displaying, and diagnostics.

***Examples:***

* The software **"Pokémon GO"** is one of the greatest instances of augmented reality. So, what that game does is it superimposes digitally made Pokémon pictures over our real-world perspective, which we can see through our phone's camera.
* Augmented Reality is built right into Google Glass and other head-up displays (HUDs), such as the Vuzix Waveguide Lens. These glasses might be used as medicine reminders for patients. Soldiers wearing these might have access to real-time combat data.

AR apps usually link digital animation to a special 'marker,' or determine the location with the use of GPS in phones. For example, overlaying scores to a live stream athletic event. Augmentation occurs in real time and within the context of the environment.

Today, there are four forms of augmented reality:

1. **Markerless AR:** Markerless Augmented Reality (AR) is a software programme that overlays virtual 3D material into a scene and holds it to a fixed point in space without requiring prior knowledge of the user's environment.

**How does Markerless Augmented Reality work?**

Markerless augmented reality (AR) combines digital data with real-time, real-world inputs that are recorded to a physical location. To register 3D images in the actual environment, the technology blends software, audio, and video graphics with the cameras, gyroscope, accelerometer, haptic sensors, and location services of a smartphone or headset.

Without any prior knowledge of the surroundings, Markerless AR recognizes objects or distinguishing features of a scene, such as walls or junction points. The visual effect that merges computer images with real-world footage is commonly linked with the technology. The earliest markerless systems interacted with available AR resources and defined a device's position and orientation in space using the device's location services and hardware.

**Markerless AR is everywhere**

The introduction of improved camera systems, mobile operating systems (OS), and sensor technologies in common mobile devices such as the iPhone aided in the accessibility of complex AR applications. Markerless AR is available to everyone with a contemporary smartphone or tablet running the most recent version of Android or iOS.

**Different Types of Markerless AR Systems**

Markerless AR superimposes virtual items over a static, pre-captured 2D image in its most basic form. Of course, this isn't the most advanced technique and blurs the boundary between augmented reality and picture manipulation. However, for apps that wish to provide offline AR instead of live experiences, it's simple and uncomplicated to execute.

On the other end of the spectrum are markerless AR systems that rely on RGB-D SLAM and sensor fusion techniques. The best-known example is Microsoft's HoloLens. These systems combine data from RGB cameras with state-of-the-art infrared time-of-flight cameras to create a 3D map of the user's surroundings while they use the app. This functionality is an important part of the SLAM tracking paradigm since it allows apps operating on these devices to concretely put virtual content in the area.

**Advantages of Markerless AR Reality**

* When you have AR, your average range of motion increases dramatically.
* With a mobile device or a see-through headgear such as glasses or goggles, you may start the application from anywhere.
* You may tell others about your adventure.
* When viewing AR information, you have a larger field of vision.

**Disadvantages of Markerless AR Reality**

Despite the advantages of markerless AR technology over previous systems, there are still limitations. To produce virtual graphics, the technique is largely reliant on flat, textured surfaces. Apps on mobile devices also consume a lot of power.

Due to a lack of acceptability for AR wearables (glasses or headsets) and commercial investments, adoption is delayed.

**Pros and Cons of Markerless AR**

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| --- | --- |
| **Benefits** | **Challenges** |
| AR may help you increase your range of motion. | Surfaces that are flat and textured are required. |
| To start an AR app, put on a headset. | Apps that operate on mobile devices need a lot of energy. |
| Tell others about your experience. | Adoption is taking its time. |
| AR content with a larger field of view |  |

**Markerless AR Software Applications**

User-centric markerless tracking in VR headsets will facilitate boundless virtual environments that can adapt to various commercial uses. Markerless AR software applications that track motion within a space has enormous potential to impact autonomous vehicle and robotics technology.

Imagine upgraded motorized wheelchairs with integrated markerless tracking technology. Wheelchair users could navigate the physical world with built-in obstacle avoidance and safe pathfinding features. They would use a headset with integrated eye-tracking and look at a place in front of them to activate. Autonomous vehicles could use the same innovations for navigation.

1. **Marker - Based AR:** The AR experience in marker-based AR, also known as image recognition AR, is activated by a trigger photo or QR code. The user may use their phone camera to scan the marker, and the digital experience will emerge on top of it. The user may move around the marker and perceive the digital experience in 3D as a result.

Marker-based AR might be cloud-based or device-specific. Because the AR elements are pre-downloaded to the user's device via the app, a localized AR experience may be watched right away. Because the AR components must be downloaded from the server, a cloud-based AR experience may take a few minutes longer to load.

The marker must be distinct in order for the camera to recognize it. Logos, packaging, signs, bottles, machines, and other items can all be used as markers. It's ideal to use images with distinct corners, colors, and edges.

AR with markers is ideal for marketing and gamification. It has been proved that using marketing materials increases brand engagement. Forget about the dull static materials of the past; firms can now stand out by offering customers exciting and engaging brand experiences.

**Pros**:

* For first-time AR users, the interface is simple and user-friendly.
* With marker-based AR, tracking is extremely reliable.
* Cost of manufacturing at a minimum.

**Cons**:

* Only when the camera is close to the marker does it operate.
* The AR overlay has troubles if the marker picture has light shining on it.
* The tracking will be unreliable if there are no strong color differences.
* One last disadvantage is that the app relies on the presence of a distinct item, such as marketing material, to initiate the experience. AR that does not need the use of a marker can be utilized at any time and in any location.

1. **Projection – Based AR:** Projection Augmented Reality, often known as "spatial Augmented Reality," is a way of providing digital information to people in a fixed environment. The zone in which AR experiences take place is confined to the fields of view of both the stationary projector and the accompanying camera for tracking.

**How it Works**

One or more optical devices (projectors) project a beam of light onto a specifically constructed work surface and, in certain situations, directly onto the components on which a user is working. This gives jobs quick direction and eliminates the need to interrupt workflows to look for information.

Projection-related workspace any of a number of stationary cameras can be used in Augmented Reality. With or without fiducials, cameras are placed to track things. The tracking algorithms' computational complexity is reduced by controlling the workplace environment, such as illumination.

The projection Augmented Reality system may deliver user instructions or help in a number of media after it's been configured. Digital information, for example, can be:

* Cycle time countdown, for example, is a text example.
* For example, blueprints or simple directing arrows are examples of images.
* Animations
* Videos

Some systems also offer task-synchronized audio as a form of support.

**Benefits of Project Augmented Reality**

The following are some of the advantages that Projection Augmented Reality may provide:

* Because the instructions display immediately in the job environment, it reduces or eliminates the need for computer monitors and screens.
* Because there is no need to "attention switch" between work instructions and the job at hand, users' cognitive burden when following work instructions is reduced.
* Integrates with manual procedures by encouraging a "no faults forward" policy to ensure and validate that the previous step was completed correctly.
* For process optimization, traceability, and unique digital IDs for build cycles, provides feedback on performed activities.

1. **Superimposition – Based AR:** Superimposition AR replaces an original view of an object with an augmented view of the same item in either a partial or full replacement. Object identification is critical in this form of AR since an app can't replace an original object with an augmented one if it can't recognize it. Social media sites like Instagram, Facebook, and Instagram have popularized this style of AR through the use of filters.

**Brief History of Augmented Reality (AR)**

* **In the 1960s,** AR was quite popular. Ivan Sutherland and Bob Sproull produced The Sword of Damocles, the first head-mounted display, in 1968. It was obviously a crude gadget with basic computer graphics.
* **In the 1970s,** AR was quite popular. Myron Krueger founded Video place, an artificial reality laboratory, in 1975. Human motions would be used to interact with computer objects, according to the scientist. Later on, same notion was used to projectors, video cameras, and onscreen silhouettes.
* **In the 1980s,** AR was quite popular. Steve Mann created the first portable computer, the Eye Tap, in 1980. It was meant to be worn in front of the eye. It captured the scene and then added effects to it, as well as displaying it to a user who could interact with it through head motions. Douglas George and Robert Morris created the first prototype of a heads-up display in 1987. (HUD). It projected astronomical data into the sky.
* **In the 1990s,** AR was quite popular. The phrase "augmented reality" was coined in the year 1990. It initially emerged in the work of Boeing researchers Thomas Caudell and David Mizell. The AR system "Virtual Fixtures" was invented by Louis Rosenberg of the United States Air Force in 1992. In 1999, a team of scientists led by Frank Delgado and Mike Abernathy put new navigation algorithms to the test, generating runways and street data from a helicopter video.
* **AR in the twenty-first century.** Hirokazu Kato, a Japanese scientist, created and released AR Toolkit, an open-source SDK, in 2000. It was later tweaked to work with Adobe. Trimble Navigation unveiled an outdoor helmet-mounted AR system in 2004. The AR Travel Guide for Android mobile devices was created by Wikitude in 2008
* **Today's AR** is Google Glass, which connects to the internet through Bluetooth, was beta tested in 2013. Windows Holographic and HoloLens were two fresh new technologies introduced by Microsoft in 2015. (An AR goggles with lots of sensors to display HD holograms). Pokémon Go was released on mobile devices by Niantic in 2016. In just its first week, the software blew up the gaming business, earning $2 million.

**How does Augmented Reality work?**

A variety of data (pictures, animations, movies, and 3D models) may be utilized in AR, and the output can be seen in both natural and manufactured light. In addition, unlike VR, users are aware that they are in the actual environment, which is enhanced by computer vision. AR may be seen on a variety of devices, including screens, glasses, portable devices, cell phones, and head-mounted displays. It includes **S.L.A.M.** (simultaneous localization and mapping), **depth tracking** (basically, sensor data that calculates the distance to objects), and the following **components**:

* **Cameras and Censors:** Data regarding user interactions is collected and sent to be processed. Gadget cameras scan the environment, and using this information, the device locates actual things and develops 3D representations. It might be special-purpose cameras, such as those found in Microsoft's HoloLens, or regular smartphone cameras for taking photos and movies.
* **Processing:** AR gadgets should someday behave like little computers, as current smartphones now do. To be able to measure speed, angle, direction, orientation in space, and so on, they need a CPU, GPU, flash memory, RAM, Bluetooth/Wi-Fi, a GPS, and so on.
* **Projections:** On AR headsets, this refers to a little projector that accepts data from sensors and projects digital material (the result of processing) onto a viewing surface. In truth, the usage of projections in augmented reality has yet to be completely developed for commercial products or services.
* **Reflection:** Mirrors are included in certain AR systems to help human eyes in viewing virtual pictures. Some contain an "array of tiny curved mirrors," while others have a double-sided mirror that reflects light to both the camera and the user's sight. The purpose of such reflection routes is to align the images properly.

**Augmented Reality Devices**

Augmented reality is already supported by a large number of current gadgets. These technologies are constantly evolving, from smartphones and tablets to Google Glass and portable devices. AR devices and hardware, for example, must contain sensors, cameras, accelerometers, gyroscopes, digital compass, GPS, CPUs, displays, and other features for processing and projection.

The following are the types of devices that are suited for augmented reality:

* **Mobile Devices:** The most widely accessible and well-suited for AR mobile apps, which range from pure gaming and amusement to corporate analytics, sports, and social networking.
* **Special AR Devices:** Specifically created for augmented reality experiences. Head-up displays (HUD) are an example of data being sent to a transparent display right into the user's perspective. Originally designed to educate military fighter pilots, similar technologies today find use in aviation, the automobile industry, manufacturing, sports, and other industries.
* **AR Glasses (or smart glasses):** Google Glasses, Meta 2 Glasses, Laster See-Thru, Laforge AR glasses, and other similar devices are available. These machines can show smartphone alerts, aid assembly line employees, and access information hands-free, among other things.
* **AR Contact Lenses (or smart lenses):** Taking Augmented Reality to the next level. AR lenses are being developed by manufacturers such as Samsung and Sony. Samsung is developing lenses as a smartphone attachment, while Sony is developing lenses as standalone AR gadgets (with features like taking photos or storing data).
* **Virtual Retinal Display (VRD):** By directing laser light into the human eye, pictures may be created. Such systems, which aim for bright, high contrast, and high-resolution pictures, have yet to be developed for practical application.

**What are the applications of Augmented Reality?**

1. **Defense:** Using AR technology, it aids soldiers in enhancing their situational awareness. Tactical Augmented Reality is the name of the technology (TAR). This device features an eyepiece that allows soldiers to precisely determine their locations on the battlefield, as well as the positions of others (friends and enemy soldiers).

**The technology's impact:**

* Night vision goggles will be replaced with TAR in the future, as this technology can assist warriors in the dark.
* It will take the place of the portable GPS units that soldiers currently use to find their whereabouts.
* The eyepiece is linked to a thermal location on the troops' weapon or carbine through a wireless connection. The picture of the target, as well as other data like as the distance to the target, may be viewed through the eyepiece when the soldier is directing the weapon.

1. **Advertising:** Jaguar Land Rover, for example, put potential automobile customers in the virtual driver's seat of its latest models without having to visit the showroom. Consumers may activate AR immediately from a banner ad without having to download an app. Through clear windows, customers sat in the driver's seat may see the outside view.
2. **Healthcare:** Handheld ultrasound scanners have traditionally been used in reconstructive surgery to locate blood arteries and bones. However, AR technology has the potential to replace ultrasound scanners since it can more precisely and quickly locate blood veins.
3. **Pharmaceuticals:** Scientists can use augmented reality techniques to visualize the structure of complicated compounds. Typically, drug developers use static models. The AR will allow engineers to take a look inside the molecule to watch how it moves and reacts to various stimuli and circumstances. This will cut down on mistakes and shorten the years-long medication development process.
4. **Logistics:** At numerous levels of their operations, AR will assist the logistics industry.

* Warehouse operations are being optimized.
* Transportation optimization
* Deliveries to the last mile
* Value-added services have been improved.

**Other applications of Augmented Reality**

* Augmented Reality is exemplified through various Snapchat and Instagram filters.
* When you scan your QR code with your phone's camera, further information appears on the screen.
* Augmented Reality is built right into Google Glass and other Head-up Displays (HUDs). These glasses might be used as medicine reminders for patients.
* It is used by retailers to assist clients in visualizing aesthetics when new furniture is installed in their homes to revamp the interiors.
* Gaming one of the most well-known games to have struck a chord with the general audience is Pokémon.
* In the realm of language translation, AR is utilized.
* Law enforcement authorities can utilize augmented reality technology to identify criminals in large groups.
* When a car breaks down, individuals may use AR technology to repair and maintain their vehicles without the need for a technician. This tech will use object recognition to detect car parts, then explain and photograph all essential repair and maintenance tasks in detail and in real time, as well as any equipment needs.

**The Pros of Augmented Reality: Benefits and Applications**

AR's uses stem from the fact that it augments or supplements the actual environment with sensory data supplied by a computer. The following are some of the unique advantages and applications:

* **Best of Both World:** One of the most important characteristics of AR is that it mixes the real and virtual worlds. As a result, one of its benefits is that it enhances the natural environment's experience by overlaying virtual information on top of it. New gaming experiences, interactive navigation, and tourism are among of the uses.
* **Immersive Communication:** AR enhances digital communication by adding virtual information to make it more immersive. This may be used in interactive and participatory learning, distant education, and corporate remote collaboration, among other things. AR enhances human-to-human contact via digital communication devices.
* **Supports Business Activities:** Another benefit of augmented reality is that it may help businesses improve their processes. Retailers may utilize augmented reality to illustrate or advertise their items. Employees can use technology to promote remote work, as previously said. AR may also be applied to product development, particularly in the areas of design and testing.
* **Extends Smart Devices:** AR expands the capabilities and functionality of gadgets like smartphones. AR is being used in a variety of apps, including real-time text translators, filters for camera and social media apps, and interactive maps with Comprehensive Street and topography data. It's worth noting that AR enhances how people engage with computers.

**The Cons of Augmented Reality: Limitations and Drawbacks**

* **Privacy and Security Concerns:** The gathering, processing, and analysis of enormous volumes of data is a key drawback of augmented reality. As a result, in addition to the disadvantages of Big Data, it is plagued by privacy and security concerns.
* **Issues about Intrusiveness:** Still, when it comes to privacy and security, AR systems that capture the surroundings in real time are available. In areas with severe privacy regulations, taking photographs of random persons and their private properties, as well as recording their talks, might cause legal concerns.
* **Can promote risky behavior:** The game Pokémon Go revealed the limitations of augmented reality. AR can mask hints in the actual world since it adds virtual information to the natural environment. Some of these indicators are designed to assist people avoid danger. Nonetheless, technology has the potential to make a person less aware of his or her environment.
* **It can be costly:** The augmented reality game Pokémon Go exposed the limits of the technology. Because AR adds virtual information to the natural environment, it might hide indications in the real world. Some of these cues are intended to help individuals avoid dangerous situations. Technology, on the other hand, has the ability to make a person less conscious of their surroundings.
* The accuracy of GPS is just approximately 30 feet (9 meters) and it does not perform well inside. People may not always be ready to rely on their little devices for overlaid information. There is such a thing as having too much knowledge.

**Difference between Augmented Reality, Virtual Reality and Mixed Reality**

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| **Augmented Reality (AR)** | **Virtual Reality (VR)** |
| The system adds to the existing scene. | Virtual world that is completely immersive |
| In augmented reality, the user is always aware of their presence in the actual environment. | The visual senses are controlled by the system in virtual reality. |
| AR is made up of 25% virtual content and 75% actual content. | VR is made up of 75% virtual content and 25% actual content. |
| This technology immerses the user in the activity to a degree. | This technique immerses the user completely in the activity. |
| AR may use up to 100 Mbps of bandwidth. | A connection of at least 50 Mbps is required for VR. |
| There's no need for an augmented reality headset. | An augmented reality headset isn't required. |
| End-users may engage with virtual items that are closer to them while still being in touch with the actual world. | The VR user is secluded from the actual world and immersed in a wholly fictitious universe when utilizing VR technology. |
| Both the actual and virtual worlds benefit from it. | It's employed in the game industry to add to the realm of fiction. |

**Conclusion**

**Case Study**

*Use of Augmented Reality in Pharma Company to transform on-the-job training*

* A worldwide pharmaceutical business needs to modernize its training and improve its standard operating procedures.
* They're building work aids to go along with SOPs using PTC's Vuforia Expert Capture — an augmented expert assistance and training solution.
* Improved work assistants will boost productivity by streamlining worker training, reducing mistakes and operational expenses.
* The potential cost reduction per plant is anticipated to be $27 million.

**Challenges**

A prominent multinational pharmaceutical firm sought to simplify training and remove manual Standard Operating Management (SOP) management on the manufacturing floor to decrease error and boost efficiency.

**The Manufacturer: An Industry - leading Pharmaceutical Company**

They are one of the world's largest pharmaceutical corporations, with billions of dollars in revenue and thousands of workers. Many of the world's most well-known medications and vaccines are part of their product line. Every day, their people work to raise the bar for quality, safety, and value in the manufacturing of healthcare goods in a variety of markets throughout the world.

**Background: Paper - Based SOP’S Affecting Factory Productivity**

The complexity of pharmaceutical production is continually growing. This necessitates more complex procedures, efficient training, and a higher requirement for front-line staff to retain their expertise. Long standard operating procedures (SOPs) and "read-and-understands" are an important element of training, but they can be unnecessary and difficult to follow for the modern digitally minded workforce. In a highly regulated, quality-driven workplace, introducing new technologies is necessary to keep their team engaged, motivated, and productive, but it may be difficult.

According to the customer, new employees must study 250 standard operating procedures (SOPs) before being authorized to operate on the manufacturing floor. Strong work aids accompanying SOPs help workers to be educated more effectively, resulting in more confidence, improved information retention, shorter training time, increased productivity, and fewer errors. This worldwide industry leader was seeking for methods to boost efficiency and cut expenses, particularly in the area of administering hundreds of SOPs.

**The Challenges: Operator Error and Manual SOP Management**

*Biggest Challenges*

* Capturing the expertise of their technical specialists
* Reducing downtime and scrap caused to operator mistake
* Improving training and the efficacy of SOPs

Experts in technical fields are few, yet their expertise is in high demand. They are regularly drawn away from their main responsibilities for new recruit training and debugging operator error-related problems. Improved operator training may have a significant influence on manufacturing productivity in an industry with a high turnover rate.

Their methods were more prone to operator mistake due to two variables. The first was the difficulty of quickly locating and updating their hundreds of SOPs. Another concern was the inherent difficulty of adhering to paper-based SOPs for more complex operations like line clearing. Increased downtime and scrap material were also a result of these circumstances.

The existing approaches for capturing expert information and managing SOPs are ineffective - there are too many processes and not enough context or knowledge retention for SOPs to be successful.

The project's primary motivation was to reduce scrap surrounding line clearances, which occurs when vessels and pipes are cleaned out for the following batch of goods. Frontline employees who follow paper-based SOPs for such a complicated operation generally trash 10% of their product yield while also working slower and with opportunity for improvement. The corporation is losing millions of dollars in unrecoverable goods and time as a result of these circumstances.

To that aim, they want to better capture expert knowledge, increase training, decrease operational mistakes and trash, and improve their hundreds of SOPs with work assistants.

**The Approach: Tested different Augmented Reality Software Solution**

This multinational pharmaceutical corporation began seeking for software that would provide guided training, especially using augmented reality (AR) or aided reality. They compared a few different providers, putting each one through its paces on-site with their employees and innovation team.

They looked at the following criteria:

* Is it able to suit the needs of a certain user?
* What is the setup and use process like?
* Is it effective at retaining knowledge?
* How well does it increase productivity and decrease mistakes while improving SOPs?
* Could they be a co-developer of solutions to satisfy their business's needs?

Everyone agreed that PTC's Vuforia Expert Capture provided the greatest user experience of all the AR systems they tried. "I can't believe how easy this is," one of their specialists stated. Within 20 minutes, they were ready to go.

They began by identifying production use cases, spoke about hardware acquisition and training, and came up with ideas for how to sustain and expand this solution inside their business with the help of PTC.

**Use Cases: Where Vuforia expert capture Solution Adds Value**

There are two scenarios in which this method is quite useful:

* **Enhanced training:** Providing refreshers for operations that occur infrequently yet are highly difficult to do, such as syringe pump cleaning.
* SOPs with augmented work aides: Within widely used SOPs, providing visual help for highly technical tasks.

These two use cases help the organization in a variety of ways, including just-in-time operator training, improved SOP management, and more efficient production and lab operations, and they empower their employees to do the job properly the first time.

**The Solution: Vuforia Expert Capture makes everyone an Expert**

The industry-leading corporation began to roll out Vuforia Expert Capture, as well as 2D and 3D hardware, for various processes based on the early findings and PTC's direction.

Vuforia Expert Capture makes it simple to collect tacit information from experts and convey it to less experienced people in a consumable fashion. The non-expert operator may then do the exact same actions as the expert in a fraction of the time and with the same level of understanding and result. The previous method of knowledge transfer was not scalable; our approach addressed that hole.

A certain method, for example, was only known by one person in the plant. Normally, training someone to do it successfully would take a long time, but Vuforia enabled others in the factory to learn the method fast and precisely using contextual step-by-step augmented reality-based instructions.

SOPs that have been significantly improved can then be seen on Microsoft HoloLens devices.

**Expected Results: Save Millions on Line Clearance Activities**

In today's society, the expert spends a significant amount of time instructing non-experts on how to perform the task. With Vuforia, once an expert captures a job with a wearable, it can be converted into a consumable format in less than an hour, allowing them to shorten their training time in half or more.

Furthermore, the corporation spends hundreds of millions of dollars every year attempting to recoup from the consequences of faulty line clearance. They are supposed to offer proper and repeatable clearance of each of their lines with Vuforia. Batches will be less likely to be scrapped as a result of this. As a result, they will save millions of dollars on line clearing tasks thanks to PTC's AR technology.

**The Outcome: A less stressful Workplace with Higher Productivity**

When you can't locate the perfect SOP, it's frustrating, and it's much worse when a small error results in erroneous line clearance. For complicated operations like line clearing, following a paper-based SOP is prone to mistake. Technical specialists are regularly enlisted to assist in the resolution of such issues. This multinational pharmaceutical corporation has discovered a more effective technique to teach employees and gather specialist information in order to reduce operator error.

The customer is beginning to demonstrate that SOPs may be enhanced by using Vuforia Expert Capture at six distinct locations. Vuforia's easy user experience has resulted in rapid adoption. They plan to minimize operational expenses, expedite worker training, and make better use of their process specialists' time after implementation. Based on their findings, they will increase production and cut expenses, possibly saving $27 million each factory.