CAMERA AI BASED REPLENISHMENT SYSTEM

Sachin More[1], Gajendra Deshpande[2]

[1] Leading Tech Transformation and Strategy, United State

[2] Eysec Cyber Security Pvt Ltd, Belagavi, Karnataka, india

Abstract: The disruption of the worldwide supply chain and logistics distribution caused by COVID-19 is well known, and it presented a new set of commercial issues The issue of inaccurate inventory is causing retailers to struggle. Inventory is a crucial component in creating the proper order demand and plays a significant part in assessing shop demand. The potential for a camera AI-based inventory management and replenishment system is enormous, notwithstanding the usage of more conventional techniques like cycle counts and third-party inventory services. Since some slow-moving items make it difficult to interpret the product sales pattern, a quantity of machine learning models consumed remained employed to determine theoretical inventory based on previous transactional data (time series). However, these models have not been able to address the issue of inventory inaccuracy. Although slow-moving items may not account for a large portion of sales (the 80-20 rule), they may assist draw people to the store, generating indirect revenue.

Keywords— AI Camera, ERP, Edge Computing, Inventory management, Generative AI, Retail Inventory management.

I. INTRODUCTION

A camera-based artificial intelligence system that can work with the replenishment engine is required to generate high-quality replenishment orders that guarantee client loyalty and business expansion. According to the loyalty index, if a consumer cannot find what he is looking for, he will not want to return, which will have a direct effect on the company's profitability. The goal of camera AI-based technology is to periodically scan store shelves, analyze the images using the planogram for each store, generate useful metrics and information in a format that can be read by the system, and send it back to the ERP. It focuses on indicators that affect the engine's decisions about replenishment and provides the intended outcomes for store orders. This is not only limited to slow-moving but can be extended to all the products including seasonal items. The more accurate store shelves are filled with products, there is the likelihood of customers visiting the stores regularly helping in customer retention and consistent sales. Other opportunities are being explored for sales price optimization which would help in the best price determination.

Edge Computing for Camera AI-Based Store Inventory Management: A Revolution in the fast-paced world of retail, efficient inventory organization is essential for success. The integration of artificial intelligence (AI) & edge computing with camera systems is transforming the way stores track and manage their inventory, important. to enhance competence, exactness, and consumer gratification.

The Power of Edge Computing: Traditional inventory management systems often rely on manual processes or centralized cloud-based solutions. However, the advantage of dividing transport dispensation control earlier to the information foundation, in this circumstance, the cameras within the store. This offers several advantages.

Real-time Insights: Edge computing enables real-time analysis of camera feeds, allowing for immediate detection of stock levels, out-of-stock items, and misplaced products. This empowers store staff to take corrective action promptly.

Reduced Latency: Through dispensation information nearby, the advantage of subtracting reduces latency, ensuring faster response times and a seamless shopping experience for customers.

Bandwidth Efficiency: Advantage subtracting decreases the essential to communicate huge quantities of numbers to the mist, redeemable bandwidth and dropping prices.

Enhanced Privacy and Security: Handling data at the edge can help address privacy concerns by minimizing the transmission of sensitive customer information.

AI-Powered Camera Systems AI algorithms production a critical part in analyzing camera feeds and extracting valuable insights. Computer vision models can:

- **Identify and Track Products**: AI can accurately recognize and track individual products within the store, even in crowded environments.

- **Monitor Stock Levels**: By analyzing shelf space and product quantities, AI can provide real-time updates on stock levels, triggering alerts when replenishment is needed.

- **Detect Misplaced Items**: AI can identify products placed in the wrong locations, enabling staff to quickly rectify errors and maintain store organization.

- **Analyze Customer Behavior**: By tracking customer movements and products, AI can generate valuable insights for marketing and store layout optimization.

Benefits of Edge Computing and Camera AI for Inventory Management

- **Improved Inventory Accuracy**: Real-time monitoring and AI-powered analysis significantly reduce errors anddiscrepancies in inventory records.

- **Optimized Stock Levels**: By accurately tracking stock levels and predicting demand, stores can avoid overstocking and stock outs, minimizing waste and lost sales. organization is essential

- **Enhanced Operational Efficiency**: Automation of inventory management tasks frees up staff to focus on customer service and other value-added activities.

- **Personalized Shopping Experiences**: By examining consumer performance and predilections, supplies can proposal modified commendations and promotions, improving the shopping experience.

The Future of Retail Inventory Management: The convergence of edge computing, AI, and camera systems is revolutionizing store inventory management. As these technologies remain toward change, we canister imagine straight better heights of mechanization, accuracy, and personalization in the retail industry.

Solving Store Inventory Inaccuracy using Edge Computing and Generative AI: Inventory inaccuracy is a pervasive challenge in retail, leading to out-of-stocks, overstocking, and lost revenue. Traditional inventory management systems often struggle to keep up with the dynamic nature of retail environments. However, the convergence of edge computing and generative AI offers a promising solution to this longstanding problem.

The Role of Edge Computing: Authority adding fetches data dispensation nearer to the basis, permitting present investigation & supervisory. In the context of inventory management, this means that data from shelf sensors, cameras, and point-of-sale systems can be processed instantly at the store level. This eliminates latency and allows for immediate responses to changes in inventory level.

Generative AI's Impact: Generative AI, a subset of artificial intelligence, can create new data instances that resemble existing data. In inventory management, this capability can be used to generate synthetic data that augments real-world inventory data. This helps train machine learning models to be more accurate and robust, even with limited or noisy data.

Combined Power of Edge and Gen AI: by combining edge computing and generative AI, retailers can achieve a new equal of inventory accuracy. Edge devices can collect simultaneous information on record levels, while generative AI can fill in the gaps and create a comprehensive picture of the store's inventory. This enables retailers to brand

knowledgeable choices around replacement, estimating, and elevations. Use Cases and Benefits:

- **Real-time Inventory Tracking**: Edge computing allows for continuous monitoring of catalogue stages, as long as actual reflectiveness interested in standard stages.

- **Predictive Analytics**: Generative AI can be used to forecast demand and optimize portfolio heights, dropping the danger of standard outs and over-stages.

- **Dynamic Pricing and Promotions**: By analyzing real-time inventory data and demand patterns, retailers can

- dynamically adjust prices and promotions to maximize sales and profitability.

- **Enhanced Client Knowledge**: Correct catalogue material make sure that goods are obtainable when clienteles poverty them, refining client gratification and faithfulness.

Challenges and Considerations

- **Data Privacy**: Retailers need toward confirm that customer information is collected & recycled sensibly, complying with privacy regulations.

- **Integration with Existing Systems**: Edge computing and generative AI solutions need to be seamlessly integrated with existing inventory management systems.

- **Cost**: Implementing edge computing and generative AI infrastructure can be costly, but the potential benefits in terms of increased efficiency and revenue often outweigh the initial investment.

II. LITERATURE OVERVIEW

Since it requires an extensive range of procedures on behalf of the transportation, loading, & usage of dangerous resources, the petrochemical industry is among the most hazardous. In the petrochemical sector, hazardous emissions, explosions, and fires are possible safety risks

[1]. Faulty pipesare the cause of many gas leaks, which have caused large financial losses and environmental harm. Techniques foridentifying and preventing pipeline leaks have been proposed by several researchers. Gas leak detection technologies are constantly evolving

[2]. Recently, technologies have been developed that use ultrasonic waves to detect gas leaks

[3]. These methods are predicated on the idea that when a gas leak happens in a pipeline, turbulent flow produces ultrasonic vibrations. Proved that minor tube and casing leaks may be effectively detected using a well-leak detector based on ultra-sonication

[4]. Additionally, a microphone sensor was used to detect steam leakage that was expelled from a needle at continuous compression. Additionally, a study was carried out to validate a sensor array-based ultrasonic vapour leakage localization technique

[5]. Discovered that in an ultrasonic frequency band, the air outflow indication differs greatly from the standard indication. They discovered that the leaking noise could go through pipes and was focused at lower frequencies

[6]. A device on behalf of noticing escapes by assigning ultrasonic devices to pipes has been projected. After the success of ultrasonic signals, Seo and Lee proposed to detect leaks in oil tanks based happening additional devices such by way of compression devices

[7]. Ultrasound transmission in the MHz range is carried out with nitrogen gas, and it has been determined that smoke leakages can remain detected in off-axis and off-axis locations

[8]. Though the ultrasonic detector shows great potential, there are some limitations such as not being able to protect an enormous area after the antennae are directly involved with the channels

[9]. Perform and test the distance measurement of the ultrasonic sensor and propose the usage of bottomless knowledge as a technique on behalf of upcoming expansion

[10]. In recent years, bottomless knowledge consumers made great strides, making great strides in areas such by way of text, speech, and processer visualization

[11]. The development of unfathomable knowledge commenced in 2013, once architectures based on convolutional neural systems (CNNs) outperformed their competitors in the ImageNet competition, leading to a concerted effort by absorption knowledge procedures

[12]. The capability of bottomless knowledge replicas to study ideas signified by uncooked information and the ability to augment the capabilities of computational tools paves the method for more forms

[13]. Purpose exposure is an important assignment in processer visualization, including the cataloguing and position of objects in images

[14]. R-CNN is the original training to express that CNN can progress entity discovery associated with outdated systems. Future, Dissolute R-CNN and Sooner R-CNN remain projected to progress the correctness and quickness of board exposure

[15]. However, these enhancements are not satisfactory aimed at immediate usage. However, through the primer of Appearance After (YOLO) and One Explosion Safety (SSD), we see an alteration in produce detection

[16]. YOLO has involved the consideration of the technical open due to its actual and correctness and has developed the foundation for pattern- finding areas

[17]. The main idea of YOLO is to estimate the bounding box by dividing the image into a grid, and this process can be done directly from the grid

[18]. Established on this indication, researchers have planned numerous developments to the innovative prototypical, counting YOLOv8, and YOLOv4

[19]. The foremost developments to the inventive prototypical comprise the acceptance of newscaster containers to grip substances of dissimilar dimensions, and comprise Path Aggregation Network (PAN), Spatial Attention Module (SAM) and Feature Pyramid Network (FPN), to improve object detection of different variables feature representation. The author likewise developed the strength

[20]. In addition to education, deep learning-based algorithms are also widely used in many sectors

[21]. Unique to these important presentations is the exposure of contaminants that pose a danger to the humanoid lifetime, the situation, and additional possessions

[22]. Researchers have realized that deep learning is possible for accurate and early detection of radiation, which has taken an effective measure to prevent adverse events produced by aquatic escapes

[23]. Using optical gas imaging (OGI) and convolutional neural networks (CNN) to identify gases in images. Similarly, recommended using closed-circuit television (CCTV) video for gas distribution

[24]. This CNN technique only isolates leaks. However, they were unable to find the leak. As instant object detection algorithms improved, researchers quickly began using them for this task

[25]. Pipeline leak detection using OGI and Faster R-CNN. In another study, researchers compared the performance of YOLOv4 and Faster R-CNN for pipeline detection. Conducted a study based on acoustic images and deep learning, achieving greater accuracy than previous studies

[26]. However, the scheme can only detect the leak and cannot provide information about the location of the leak

[27]. The state of science has reached a stage where we can try to overcome environmental noise by connecting the electronic ultrasonic leakage detection technology of machines to artificial intelligence (AI) product detection technology, by remotely checking leaks such as connection points

[28]. However, to date, there is no research to prove the effectiveness of the product

[29]. In addition, when the ultrasonic vacuum cleaner is combined with the AI object detection feature, water leakage can be detected by non- diversified objects. In this study, we investigated the content of the expected leak, divided this area into more detailed information, and reached the findings

[30]. In this paper, we propose a sensor that combines these two types. Use the ultrasound camera to detect waves. Then, we use the YOLO device to capture the camera input captured by the same ultrasound camera

[31]. Our goal is to optimize the output of the two sensors to eliminate noise or false alarms generated by the sound sensor. Through demonstration tests, we have verified that the well-designed system eliminates noise and detects gas leaks

[32-34].

III. METHODOLOGY

In this paper, we propose an intelligent petrochemical plant pipeline micro leakage detection based on ultrasonic/image fusion hardware. The system places ultrasound and image fusion sensors on the surface, acquires data, analyzes it using artificial intelligence, visualizes the results, and sends visual images. The main components of this system are ultrasonic inspection cameras, artificial intelligence servers, and data storage servers, as shown in Figure 1. Additional capabilities for monitoring and networking are also included.

Figure 1 Replacement architecture

The ultrasonic camera shown in Figure 2 is an important part of oil leak monitoring; it uses ultrasonic signals measured by multiple microphone sensors to estimate the location of the leak and find the location in the image obtained from the optical camera. The equipment is waterproof/dustproof and suitable for outdoor petrochemical plant conditions.

Ultrasonic camera is an important part of oil leakage monitoring, it is designed to use Power over Ethernet (PoE) to facilitate the connection between electrical equipment and data communication communicating outdoors. The design and structure of the camera are shown in Figure 2.
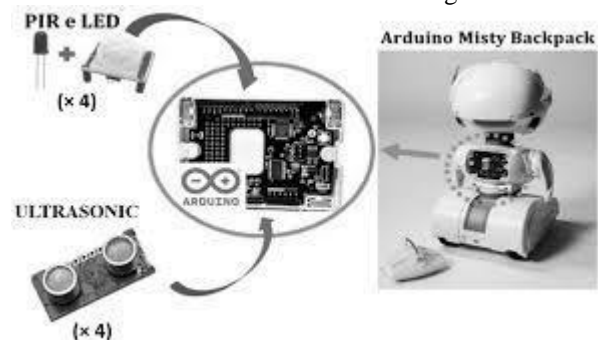

Figure 2 Ultrasonic sensor with AI camera

Visual Recognition Powered by CNN: Immerse yourself in the future of inventory management as our system leverages Convolutional Neural Networks to intelligently recognize items like nuts, oil, milk, and more from images. Benefit from the accuracy and robustness that AI-driven recognition brings to your inventory tracking.

Real-time Updates: Bid farewell to manual data entry as our system integrates seamlessly with your workflow. Experience instantaneous updates to inventory quantities as recognized by our CNN-powered visual recognition technology. This results in minimal human error and maximized operational efficiency.

User-Friendly Interface: Navigating the complexities of inventory management has never been easier. Our user-friendly interface ensures that users of varying skill levels can effortlessly capture images and manage inventory with confidence fig 3.

Figure 3 Empty Shelves at retail stores

Database Integration: Our system harmoniously synchronizes with your existing inventory database, ensuring that records are consistently accurate and up-to-date. This integration guarantees a holistic view of your inventory, empowering you to make informed decisions.

IV. RESULT & DISCUSSION

Demonstration site design and construction: We visited a petrochemical complex selected as Korea's representative petrochemical complex and set up a demonstration area with on-site analysis and drawings. The utilization process of petroleum such as liquefied petroleum gas is the largest in the petrochemical complex. The pipeline is composed of KS D 3562 (Carbon Steel Pipes for Pressure Pipes, SPPS) used in LPG process. The pipe junction uses flange connections and welded joints. The materials and installation requirements for pipe supports are comparable to those found in petrochemical facilities. Gate valves, which are frequently seen in petrochemical facilities, make up the majority of the valves in the demonstration lab. Pipe elbows are used in petrochemical facilities to lessen damage from strains caused by heat expansion and contraction. For demonstration reasons, a variety of curved shapes—including elbows—were positioned inside the pipe. As a result, as seen in Figure 1, the test site is initially created as a pipe and instrumentation diagram (P&ID) for a petrochemical facility. On this basis, a diagram of the application demonstration test case was created, as shown in the 3D diagram in Figure 4.

Open CV

I altered the input photos for my thesis using image processing methods like cvt transform and erode. The erode function efficiently breaks down the borders of objects and aids in eliminating pertinent aspects. Also, cvt Transform feature helps in transforming the images from one color space to another to make a clear distinction between white areas and objects. Also, dilate function productions a significant part in opening the double using the declared technique.
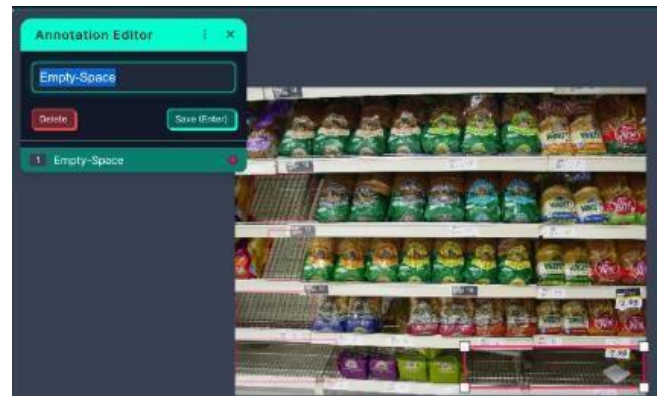

Figure 4 Labelling Images

Precision: The percentage of accurately detected empty shelves out of all expected empty shelves is known as accuracy. It is crucial to this research since it shows how well the system detects empty shelves. High accuracy indicates that the system is confident in its ability to identify the empty area because there are no false alarms.

Recall: Remember, it is still very sensitive to search or the real value, measure the empty rate of the entire shelf. This is important because indicates the system's ability to identify all shelf bases currently in stores. The reward value means lower price, which means the system can make the most of the shelf (Figures 5, 6 and 7).
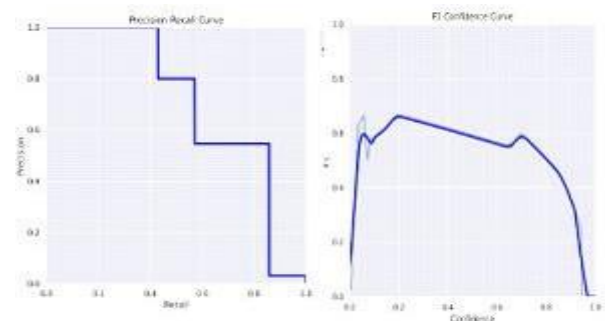

Figure 5 Precision & Recall

The figure below shows the predictions when the confidence level drops to 15% and 6%. When the value is 15%, the model can predict 75% of the free space, and when the value is 6%, the model can predict 80% of the free space.
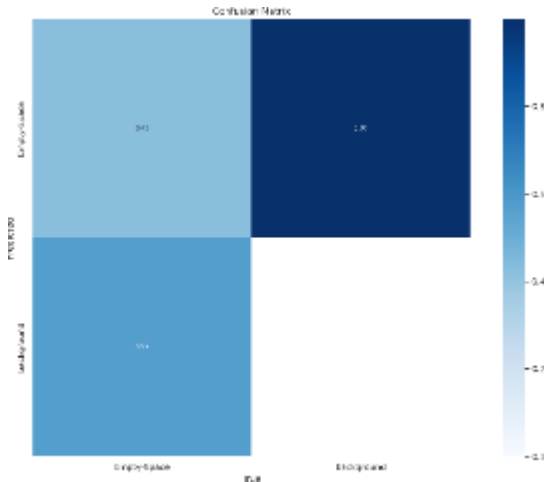

Figure 6 Empty spaces

Figure 7 Confusion Matrix

V. CONCLUSION

The combination of edge computing and generative AI presents a transformative opportunity for retailers to address the challenge of inventory inaccuracy. By leveraging these technologies, retailers can achieve real-time inventory visibility, predictive analytics, dynamic pricing, and an enhanced customer experience. As this knowledge remain to progress, we container imagine uniform superior progressions in inventory management and retail operations.

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