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Voice-based Indexing System in Warehouse Management using AI-Driven Voice-Assistants

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***Abstract* – Voice indexing optimization involves the process of optimization of keywords and keyword phrases for searches using voice assistants. Voice indexing optimization has become a major digital trend of the future and has gained immense mileage due to its convenience for a user to speak with an assistant rather than to type, which also provides faster results. There are a variety of voice-activated technologies on the market (for example, Cortana, Amazon's Alexa, Google Assistant, and many more to come). The AI technology behind voice search has become immensely accurate which has grown to 95% since 2013. The use of voice indexing in supply chain management can provide large improvements in accuracy, efficiency, and return on investment. The system utilizes the interfacing of AI-driven voice-assistants to aide in the picking, replacing, and replenishing of articles, components, goods stored in warehouses and inventories thereby cutting labor costs significantly.**

Key words* – *Artificial intelligence, inventory management, smart automation, voice assistant, voice indexing, voice search, warehouse management

I. INTRODUCTION

Any types of production lines or manufacturing chains are faced with the need to store their reserves, components, and tools in appropriate locations. This function is performed by warehouses or storage houses in most cases. A warehouse is an open platform, which is used for material storage. That involves a continuous picking, moving, and replenishing of inventories. Due to the presence of numerous SKUs (Storage Keeping Units) the accuracy and efficiency at which commodities are selected, moved, replenished greatly decreases thereby leading to a significant reduction in ROI(Return on Investment). Due to these disadvantages in manual operation, innovative techniques have been employed in the field of logistics, warehouse management, and supply chain management. The applications of this project cater to a wide variety of industries, which are concentrated in the area of e-commerce, manufacturing, construction, transportation, and warehouse and inventory management. In addition to this, the application of artificial intelligence in the proposed system in the form of AI-driven voice-assistants that make use of the Viterbi algorithm and Hidden Markov Model (HMM) for speech recognition and enhancement allows us to contribute further to the benefits of the proposed system. The proposed concept helps to bridge the gaps created by the scanning procedure prevalent today.

II. LITERATURE SURVEY

Supply chain management (SCM) plays a very crucial role in various industries as it determines the profits and losses incurred by an industry. Supply chain management (SCM) can be defined as, a group of entities, both organizations or individuals that play an active role in the upstream or downstream flow of products, services, finances and/or information from source to customer.

The SCM flow can be divided into three parts:

- Physical flow
- Information flow
- Financial flow

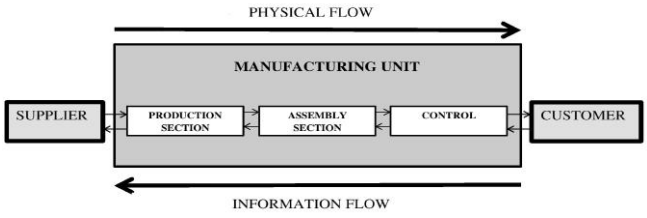

Fig 2.1: The above figure depicts the schematic flow in Supply Chain Management systems

Physical flow

It represents the flow of physical articles, components, goods etc that flows between source and customer in a supply chain management paradigm.

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Information flow

It represents the flow of critical information pertaining to the various storage keeping units (SKU) that flows between source and customer in a supply chain management paradigm.

Financial flow

It represents the flow of finances in a company starting from the transactions at the customer level up until the financial assets and transactions present at higher levels of management in a supply chain management paradigm.

The above structure of supply chain management is interchangeably applied to every industry in order to maximize the return on invest (ROI)

According to recent research carried out on supply chain management, the principles and methodologies involved in improving the accuracy, efficiency, and improving the ROI of the whole process aims at cutting down the losses incurred by the industries. It can be seen that supply chain management refers to a group of harmonized tasks for integrating suppliers, manufacturers, transporters, and customers efficiently thereby providing the delivery of the right product/service in the right quantity and at the right place [1]. Continued research in SCM shows that the efficiency and accuracy of SCM systems can be improved by advances in information systems and technology. Research also depicts that one of the major issues in supply chain management stems from information management systems.

The systems currently used to improve SCM systems include service-oriented architecture (SOA), Internet of Things (IoT), RFID, workflow management, and an agent that enables real-time quality and control management [1].

The first methodology uses industrial traceability in SCM that traces an article by tracing its origin back through the supply chain, from customer to supplier. The second uses RFID technology for automatic identification and data capture of articles that increase the efficiency and accuracy to a higher degree compared to the traceability. Using the RFID methodology, the operators use hand-held devices like PDAs connected to a web-based portal for data acquisition and information sharing in the supply chain. The RFID system was aimed at eliminating statistical errors due to human error [3]. RFID systems in recent years have been used extensively in logistics, tracking, warehouse management, mobile healthcare [3] [6-7]. RFID has also found application in supply chain management systems besides enabling automatic identification and tracking of goods [3] [7]. AuRoSS [4] implements the scanning of RFID tags of books placed on bookshelves. OTrack [5] implements mobile RFID scanning to keep a track of luggage on airport conveyors. A recent paper shows the integration of a robot and RFID scanning in chemical inventory management [3]. The system uses a robot arm that scans RFID tags present on the chemical containers as per the need [3]. But this method also caused a lot of problems in terms of inaccurate order picking, misplaced articles, and the use of a mechanical robotic arm reduces the speed of picking and scanning thereby causing a decrease in efficiency that causes significant losses to the industry. Using the RFID system created more problems than providing effective and accurate solutions. In order to bridge this gap, an attempt was made at integrating an IOT based RFID system.

In recent years, an attempt is being made to incorporate block-chain technology in supply chain management systems. Block-chain gives great impetus in the monitoring of inventories and tracking processes in the supply chain [2]. The method involves the use of a concept of hesitant fuzzy sets (HFS) that is used to express uncertainty while making decisions among several different values, especially in multi-criteria decision making (MCDM) [2].

III. PROPOSED WORK

In order to bridge the gap created by the RFID scanning technology and to achieve better efficiency, accuracy, and improved return on investment (ROI), we incorporate a voice-based indexing system in the supply chain management system. The current existing system requires a large number of operating personnel and tremendous expenditure in purchasing PDAs, scanners, and other equipment required to scan, record, and update the warehouse management system (WMS). The current procedure requires operators to traverse across large areas of the warehouse, scanning each RFID tag to find the desired product, component, or equipment making the process laborsome and laborious. By introducing voice-based control, the operating personnel can acquire the right quantity and precise position of the article at the exact location where the article is stored remotely at the fastest time required with ease.

3.1. Methodology

The system implements a voice-based tray ejection system. The system can be controlled by new-age voice assistants such as Cortana, Amazon's Alexa, Google Assistant and many more to come. These voice-assistants use statistical models called the Viterbi Algorithm and Hidden Markov Model (HMM) for speech recognition and enhancement.

There are various types of speech utterance namely:

- Isolated word
- Connected word
- Continuous speech
- Spontaneous speech

Voice-assistants are primarily trained using spontaneous speech.

In turn, there are various speaker models available[8]:

- Speaker dependent model- These systems are designed and trained for specific speakers thereby preventing multiple speakers from operating the system.
- Speaker independent model- These systems cater to a wide range of speakers and are not specific to a particular speaker. Google-assistant, Amazon's Alexa are built around this model enabling multiple speakers to interact efficiently with the system.

Voice-recognition systems also depend on the type of vocabulary being input to the system and have to be trained accordingly[8]:

- Small vocabulary
- Medium vocabulary
- Large vocabulary

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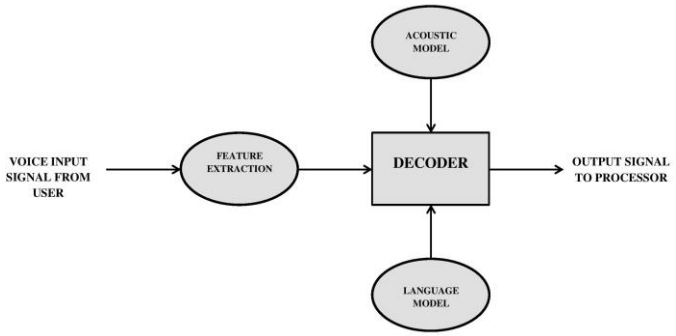

Fig 3.1: The above figure depicts the block diagram of a simple Voice Recognition System

In accordance with Fig 3.1, on receipt of a voice input (which may be either numeric, phrases, words, alpha-numeric in nature) from the user sends a signal to the processing module that carries out the necessary voice to output processing and gives a signal to the ejection system to push out the concerned tray containing the desired article. The trays can be ejected individually or simultaneously as per the requirement. This process increases the accuracy and speed of selecting, moving, picking, and replenishing goods thereby reducing the losses incurred due to inaccurate picking.

3.2. System implementation

The system comprises of the following basic sections:

- Remote voice input section
- Voice processing module
- Switching mechanism
- Execution of tray ejection
- A switched module power supply that supplies DC power to drive all the circuits and modules in the system.

The incoming voice input coming from the user via the Google voice-assistant is processed in the voice processing module, in this case, we can use an ESP8266 module as the voice processor that can be easily connected to any IoT platform such as BLYNK. This voice signal causes a data pin on the ESP8266 to go high. This incoming signal is then given to a

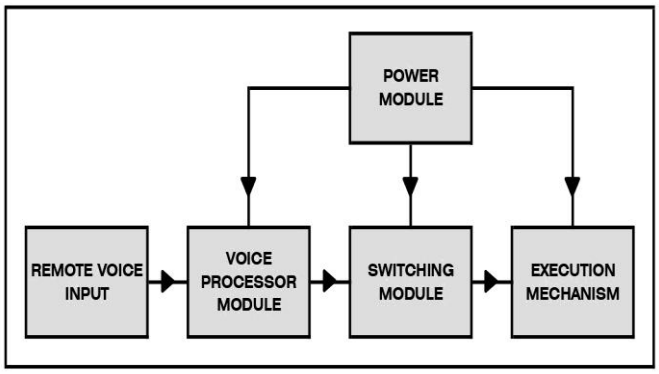

Fig 3.2.1: The above figure outlines master block diagram of the proposed system

microcontroller development board that drives the motor using a motor driver. The microcontroller development board is used as an intermediate interface to control the clockwise, halt, and anti-clockwise operation of the motor. This is needed as when the user issues a command through the voice-assistant, the command should trigger the ejection of the desired tray i.e. clockwise rotation of the motor, followed by a halt for a specific interval of time allowing the operating personnel to pick, replace or replenish the desired article/good and then the ejected tray needs to retract back into the housing after the required time has elapsed i.e anti-clockwise rotation of the motor. The power supply can be a portable switched module power supply module that drives all the circuitry and components in the system.

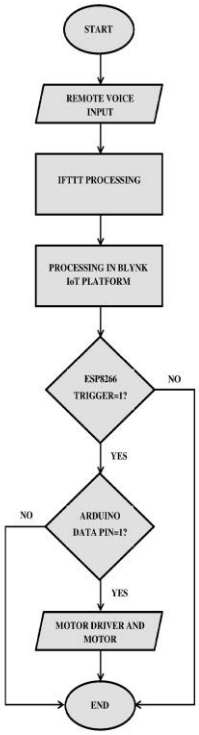

Fig 3.2.2: The above figure illustrates the flow of signals in the proposed system from the voice input-to-ESP8266-to-ARDUINO-to-motor

Fig 3.2.2 illustrates the complete flow of signals in the system. As we can see in the first decision block, the ESP8266 needs to make a choice. If the trigger signal coming from the IFTTT (which is an online platform that enables the creation of conditional applets) is HIGH or equal to logical 1 the program sends a HIGH signal to one of the ARDUINO data pins thus initiating the program loaded into the ARDUINO to drive the motor driver and the motor thus pushing the expected tray out. If the trigger at the ESP8266 is LOW or equal to logical 0, the execution branches out and the execution is terminated. Again if the signal supplied to the ARDUINO data pin is LOW, the execution branches out again terminating the operation.

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The figure 3.2.3 given below illustrates the processing and transmission of the remote voice signal in the ESP8266 module followed by the transfer of a high/low signal to the microcontroller development board that takes care of the motor direction and speed control via the program loaded into the board. An online service called IFTTT (IF-THIS-THEN-THAT) is a platform that enables the creation of numerous conditional applets that help interface various applications and devices together providing a seamless and easy form of automation. The BLYNK IoT platform is used in this system to provide a visual representation of the entire operation.

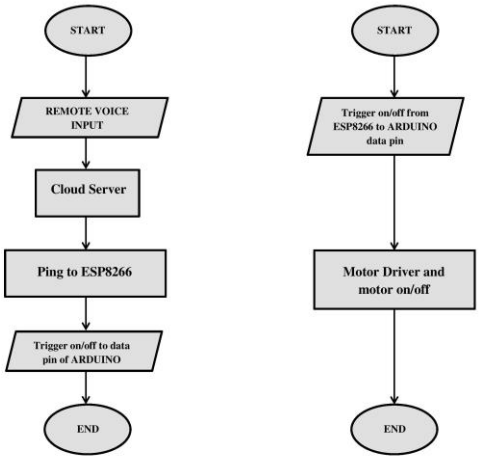

Fig 3.2.3: The above figure illustrates the ESP8266 and ARDUINO Development board execution flowchart respectively

In conclusion, the above proposed system using voice recognition can be applied to a plethora of industries and streams such as manufacturing and production lines, automotive industries, logistics, warehouse and inventory management, e-commerce and hospitals and pharmaceutical stores to improve accuracy, efficiency, and increasing ROI while decreasing inaccurate order picking, replacing and replenishing which costs tremendous losses in ROI. The lowest level of application of the above system may be in the dispensing and effective organization of medicines in pharmaceutical stores. The proposed system also bridges all the gaps created by the current existing RFID scanning system.

4.1. Benefits and scope

- The project is aimed at automating routine and monotonous tasks in warehouses and inventories.
- Increases the accuracy and speed of selecting, moving, picking and replenishing goods.
- The project aims at curbing the losses incurred due to inaccurate picking.
- This project eliminates the manual workforce required along manufacturing lines, especially in the automotive industry.
- Reduces operating costs and costs spent on employee training.

From the above two figures, fig 4.1.1 and fig 4.1.2 we can conclude that, industries producing and manufacturing large quantities require innovative technologies to curb losses, ensure effective and correct movement of goods from supplier to customer and improve the ROI of these industries.

This project can be effectively used in the following industries:

- Manufacturing and Production lines.
- E-commerce warehouse and inventory management systems.
- Automotive industries
- Tracking of patient records in hospitals.
- Pharmaceutical stores.

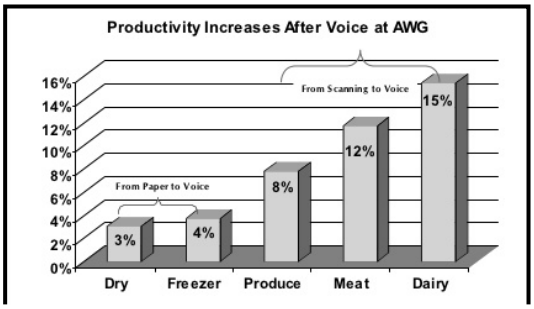

Fig 4.1.1: *Figure courtesy of a white paper by Tompkins associates* illustrating the picking productivity improvements after Voice technology implemented at AWG Kansas city [9]

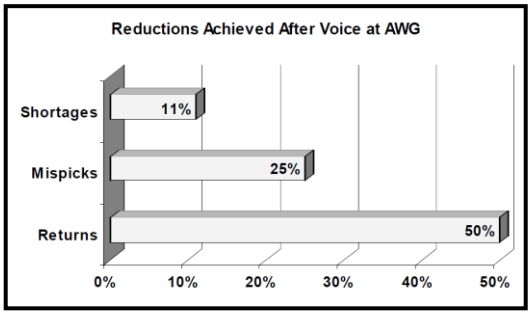

Fig 4.1.2: Figure courtesy of a white paper by Tompkins associates illustrating the reductions achieved after implementing Voice technology in AWG Kansas city [9]

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