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Design of an Intelligent Warehouse Transportation System

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ABSTRACT: *The Intelligent Warehouse Transportation System, a new way of introducing intelligence to an ordinary warehouse into preceding better transportation of goods, to storage and retrieval. The main objective is taking control of a warehouse to provide full automation, transporting goods from receiving, storage to shipping away. Many warehouses are manually controlled by humans and some are semi-automatic control, known as co-existing between machines and humans. On endeavoring technology, this led humans to be assisted by machines on heavy and repetitive tasks in orderly manners. Artificial Intelligence inducement in a warehouse involves a lot of robotics, which is quite expensive to comprehend especially in small warehouses. This article introduces a simple alternative automatic transportation system in a warehouse which basically, a warehouse integrates with smart and intelligent systems that intend to eradicate or allow less human assistance. The term smart and intelligent in some languages appear to mean the same 'intelligent' but in this article, it shows a little different. However, most warehouses prefer to go manually or semi-automatic because of technology expenses. The new technology, i-WTS is economically reasonable and easily accessible in small or big warehouses. The main concept starts from the basic which consists of three stages: (1)-Reception (2)-Storage and (3)-Dispatch. The data analysis in this article is based on an actual intelligent warehouse, programmed by PLC. The results are supported by the integration of two maneuvering software TIA Portal (automation) and Factory I/O (simulation). An iWTS is simply derived from AI-WMS, it explains literally about the transport automation of goods in Intelligent Warehouse, to storage and retrieval of a package in a modern technological version.*

KEYWORDS: iWTS – *Intelligent Warehouse Transportation System*, I/O – *Input/Output*, AI - *Artificial Intelligence*, WMS - *Warehouse Management System*, PLC – *Programmable Logic Control.*

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I. INTRODUCTION

A warehouse is a huge plain building meant for storing goods. Upon this facility, dealers are manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. Warehouses are usually located in industrial squares of the cities, towns or villages. At the center of these premises, there is a storage space containing square shelves filled with countless products. Most of the existing warehouses focus mainly on data input, data processing, and report generation. Many kinds of research nowadays manipulate results from the field of an intelligent system for the progression of the business processes within the warehouse [1].

A warehouse management system is a software solicitation that supports control and manages daily operations in a warehouse. This software directs inventory to reception and dispatch, enhances picking and shipping of orders and guides on inventory replacement [2]. An intelligent Warehouse Management System allows the management and optimization of a warehouse, storage, and internal logistics maneuvers. Intelligent Warehouse Control System sanctions automated storage and transference equipment to be abundantly controlled as one cohesive system [3].

Advanced Warehouse Management means using the latest smart technologies available to optimize efficiency, maximize the operation's productivity, and deliver the best customer experiences possible. The warehouse automation systems provide a chance to conquer a lot of tedious tasks. It widens the loading and unloading of the goods from the manufactures to consumers. There are different ways to manage a warehouse, depending on the size and targets of the organization in capital-wise [3]. The foremost technology used in these schemes is computer vision that can recognize and help unify the inventory.

Artificial Intelligent in warehouse automation is being used to forecasting the mandate for particular products [4]. The order is taken from customers and clients directed to the manufacturing unit in industry and delivers the products through a large online company like Alibaba, Amazon, eBay, and JD [5], etc. Artificial Intelligence brought a huge breakthrough, which is elucidation in the supply sequence obtained by applying results from intelligent systems to WMS processes. The i-WMS model collects several AI performances to upkeep warehouse management activities [6]. Every warehouse in the world has to undergo three common stages into functioning, namely; *Reception*, *Storage* and *Dispatch*. Intelligent Warehouse Transportation System is no exception, here below are colors that represent the substantial meaning with the flow of goods and depiction;

(1)- Reception - open cascade, the green symbolizes the entry of an item.
(2)- Storage - the main order reserves, blue symbolizes storage capacity.
(3)- Dispatch – the delivery, red symbolize the discharge of the products.

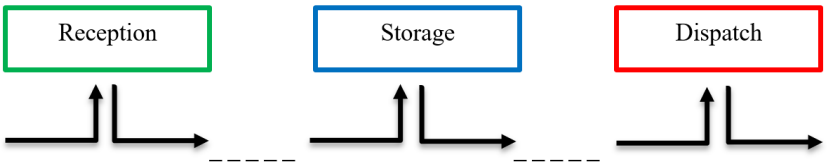

Figure 1. Flow chart of the intelligent warehouse

II. TECHNOLOGY INTEGRATION

Intelligent Warehouse is way better than a normal warehouse it contains smart (technological) ways of storing goods. Involving a sophisticated computerized integrated system, barcode scanning, wireless communication, Automatic Guided Vehicle (AGV), etc. The act of placing goods in hundreds or thousands of cubical cells, mainly programmed by PLC in management [7]. Making it convenient and simple in a large quantity of manufacturing, storing and supply to the consumers. In earlier generations of its contentment center, regular warehouse staff would have roamed these shelves incisive for the products needed to achieve in each new order [8]. Transportation of the item ordinarily enters the warehouse takes lots of heavy lifting, risk of misplacing or even break. Transport, storage and retrieve goods which appear to be time waste and sometimes may take the wrong item and send it to a different intended customer. Now the *palletizing box* (item) is glide quickly across the *conveyor* to the located *racks* (shelves) carried atop by *stacker crane*.

Warehouse Management System, using WMS focuses on striving technology, high efficiency in management and accuracy of the storage. Machinery possibly will start to assist humans with many labor-intensive tasks. It brings a lot of comforts and systematic storing order, inputting and outputting of goods [1]. Management process can be tricky if a human happens to do all the work manually in storing the parts. This draws a new trend of information, package distribution into storage, transportation of a product from the manufacturing unit (machine floor) to a warehouse and finally to the consumers. Several prototypical tactics are considered, and a multiplicity of automation intelligence and information technology are employed to assimilate the system perfectly [5]. The stored items can be of a different kind depending on the requirements, but the focused material stored in this article are machine parts- mechanical spare parts (metal). The sequence of command execution is due to demand and stored for pick up, scanned in and out of the inventory and most important is live tracking during transportation to the consumer for security and insurance purposes [6].

The Automation System, the concept is to digitize the ordinary warehouse to replace every manual work into automated. It begins with resource scheduling optimization in the market, receives a data entry on the computer for manufacturing the parts. Goods stream through the warehouse at a slow-motion pace, tracked from arrival to ship by workstation coordination. The process starts with a vision detection system of the products after they have been discharged. The software actuates by barcode recognition since it knows the parameters of each product and will automatically earmark the right box and the specifics for shipment. Further along, before products are sent to different trucks for dispatching, boxes are double-checked to make sure no mistakes have been made in packing.

Smart Technologies are implemented in warehouses to advancing the field of storage, distribution, and logistics. The warehouse has become even more prevalent with the advent of the industrial revolution when mass production of industrial goods became possible. The topology of the warehouse considers the kind of item stored and purpose it serves, can include any raw materials, packing materials, spare parts, components, or finished goods associated with agriculture, manufacturing, and production [3]. Ostensibly when technology integrates with warehouse it innovates into smart warehouse technologies; Automatic Picking Tools, Automatic Guided Vehicle (AGVs), Automatic Inventory Control Platforms, Warehouse Management System (WMS), Internet of Things (IoT) Implementation, Collaborative Robotics (CoBoTs), Automatic Storage and Retrieval System (AS/RS) [1].

Figure 2. The Intelligent Warehouse Transportation System -Frame Structure

III. TRANSPORTATION MECHANISM

Onto determine operation parameters of transport in an intelligent warehouse, we must consider the chain of events to be executed along the series of tasks and complexes to achieve. Here are four extra dependable smart systems that combined with three world's warehouse stages; reception, storage, and dispatch.

PLC Automation, A programmable logic controller or programmable controller is a digital computer used for automation of typically industrial electromechanical processes, by using ladder logic to monitor and control the machine appliances. There is a connection that links the PLC software from TIA (Totally Integrated Automation) Portal software, submitting the machine to operating for the case of sensitive controlling and executing orderly with Factory I/O. The coordination is done by PLCSim from TIA Portal via Drivers path from Factory I/O, device selected is Siemens SIMATIC S7-1500, PLC [CPU 1511-1 PN].

Inventory Database, known as demand Inquiries System, is the first stage where the order is taken into record data, specification of the part, put up for a purchase to be manufactured and delivered to the consumer. This links the IN and OUT entry system for any part which is taken to the inventory, it follows FIFO (First In First Out) and FEFO (First Expired First Out) [3]. In the case of food storage, the FEFO applies first and when dealing with decay components or material FIFO is much better. The data is documented in Excel Sheets for logistics; the number of orders to be completed, inventory of goods in the warehouse, and the total capacity of storage in a warehouse [2].

Reception; the initial package insertion that is processed across from the manufactured to the consumer. The package is sensed by the reception sensor activated to triggered Entry conveyor together with a Loading conveyor, which makes the item slide across the conveyor towards a stacker crane. While the Emitter side is ON, the Remover side stays OFF to save power consumption and disruption. In between emitter and stacker crane the goods pass the Barcode Scanner In to record an item in the system for Inventory purpose. However, if there is a case of failure in recognition of an item to the Inventory execution of the command, there is a stop button on the switchboard to halt the items in position and correct the problem, this stops the conveyor belts of Emitter and Remover.

Storage; Package picking and stacking to the Racks (shelves), there are two sides of racks to placing the goods, Left Racks and Right Racks columns. The numbering stowing order starts from 0 to 54, and 55 appears to be the original resting position or picking up and dropping off position. The items when reaching the edge of the loading conveyor the loading sensor is triggered by the package blocking the signal and stops the Entry conveyor which allows the stacker crane to slide folks right into getting the package then lifted to position 55. The item moved to the Left or Right Rack, then shoved into among of slots from 0-54, and stacker crane back to 55. In case of stacker crane misconduct or a package fall off the potting spot, there is an Emergency Stop which stops the whole system.

Dispatch; when an item is requested to be exported out of the warehouse, commanding of FIFO is preferred and the inventory database claims the release of that item. Stacker crane escalates from rest position 55 lifted to get the item from Left or Right Rack to a targeted slot (cell) [6]. Folks Left to deliver- unloading conveyor, unload sensor is triggered after Lift down the crane which activates the Unloading conveyor and Exit Conveyor to the Remover. The unload sensor is position at the center where the package is dropped, started gliding when the unload sensor is blocked by the item opens Remover. Also in between stacker crane and remover item passes Barcode Scanner Out to be recorded in the Inventory Database. At the end of the belts, there is a dispatch sensor that signalizes the package ready to be taken out and immediately stops the Remover conveyor belts to avoid goods pilling up.

Automatic Guided Vehicle, a portable robot that follows laterally marked extended lines or wires on the ground, or uses radio waves, vision cameras, magnets, or lasers for navigation [7]. AGVs are commonly used in industries to transport around freights [9]. It is programmed by a microcontroller, a compact integrated circuit

design to run a specific operation in an embedded system. It also can be used to initiates the delivery or finalizes the delivery depending on the needs of the Intelligent Warehouse, serving to reception and from dispatch. After barcode scan, transportation of part into a cubical cell for storage in and out to a loading vehicle from importers and also exported to the consumers [10].

Package Tracking System, Global Positioning System (GPS)is a satellite-based navigation system that monitoring the delivery and the distribution of parts from the warehouse to their destination [2]. After the part has been loaded by AGV to the transporting vehicle, given the name tag before shipping [9]. The items have Radio Frequency Identification (RFID) tags with inscriptions distribute the right stuff at the right place and time, the tag functions as an ID and holds its detailed information [7]. Wireless RFID sensor in the mobile device is used to check the parts that will be received by the customers, it confirms by GPRS mobile device and sends the message to the database of a warehouse (inventory database) [6]. If the part got damaged, malfunction or has a calibration problem send it back, if not it sends the feedback to the warehouse inventory database to continue with the loop of manufacturing, storage, and transport other machine parts [4].

IV. DESIGN ANALYSIS

Hereunder are the main categories to approach the system which provides users with a good package management service, for the smart design. The Intelligent Warehouse Transportation System operation components and devices that assembled are:-(a) *Electric Switch-Board;* (b)*Entry and Exit Sensors*; (c) *Barcode Scanning I/O;* (d) *Roller and Loading Conveyors*; (e) *Load and Unload Sensors;* (f) *Stacker Crane*; (g) *Rack*;

A. Electric Switch-Board

An *electric switchboard* is a device box that modulates the flow of electric perpetuation from one or more sources of supply to numerous smaller counties of usage. It is an association of one or more panels, each of which has switches that permit electrical energy to be transmitted. A switchboard has START, STOP, RESET and EMERGENCY Buttons in controlling the iWTS. Switchboards in this model of simulation ignite the conveyor belt by supply energy to the reception sensor that makes conveyors to be activated and engage in transport the item across the warehouse. In the ordinary system, there is START and STOP Button in normal operation, but in the case of malfunction in a system, an EMERGENCY Button stops the entire system.

B. Entry and Exit Sensors

The *Emitter*- an item enter the warehouse storage, green symbolizes the entry of an item. The item inserted on a roller conveyor is state to be activated during the release of the entry (reception) sensor. The sequence of an item works perfectly since it is actuated, recognized and counted, the fleet is glade on a pallet across the roller conveyor to the barcode station for recognition and counting. The *Emitter*- releases an item to be used in a scene e.g. cardboard box, pallet, etc. Whereas an item is still within the *emitter's* volume, no more items are secreted. The *Remover*- eliminates one or more items from the scene e.g. cardboard box, pallet, product lid, when they cross the remover's volume. Both Emitter and Remover can be enabled or disabled by switching tags on/off.

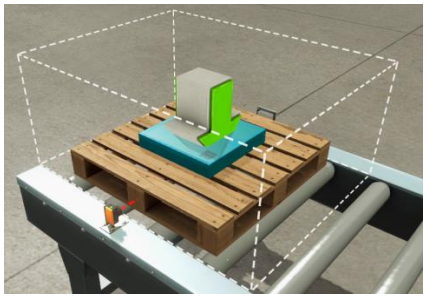

Figure 3. Emitter pallet item

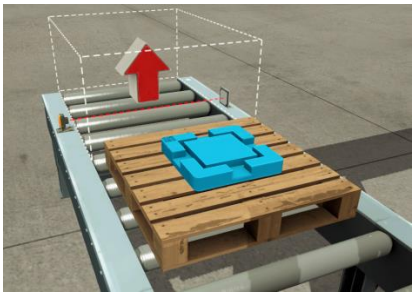

Figure 4. Remover pallet item

C. Barcode Scanning IO

The *Barcode Scanner,* usually reading and decoding are done using a scanner like a laser beam, reflects the code of the reading head in the scanner, which interprets the information stored in the lines. The barcode can consequently be seen as the special identification number of the good. The scanning process works in both ways Scan-In and Scan-Out; *Scan-In*, scanning the barcodes of the parts entering the warehouse by specifying name, size, quantity, model (kind), time of delivery (when to be transported) and which cubical cell is to be placed. *Scan-Out*, scanning process of the part to exit the warehouse to a consumer which reported to the Inventory System. The parcel scanned for memory inquiry and the mobility of demand in stock to supply at the time required [8].

Figure 5. Barcode Scan - In

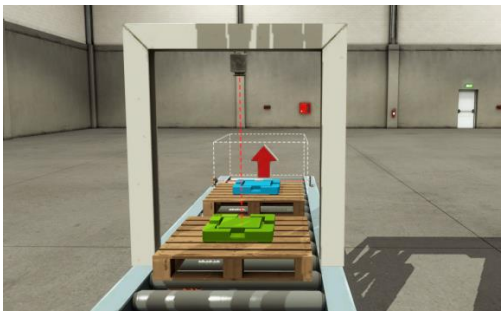

Figure 6. Barcode Scan – Out

D. Roller and Loading Conveyors

The *Roller Conveyors* are known as powered line-shaft, used in an extensive range of automatic handling installations such as feeding products to an assembly, wrapping station or machinery sortation systems, order picking through to dispatch, as shown in Figure 7. These kinds of conveyors are ideal for case handling and carton handling etc. Furthermore used in APL – Automatic Production Line in feeding, sorting, processing, assembling, and delivery keeping manufacturing innovation and improve productivity [11]. In hefty conveyance mode, transportation depends on product transference like in food handling, steelmaking, and packaging [9]. The *Loading Conveyor*, are conveyors that directly deliver a package to the pickup point or vehicle depending on the target. In this case, they are centered-hole cut line-shaft to allow a crane to pass in between to lift the pallet from one point to the storage rack or deliver to dispatch, as shown in Figure 8. These conveyors support the deliverance of goods in sequential order and time interval, for pick up and drop off.

Figure 7. Roller conveyor

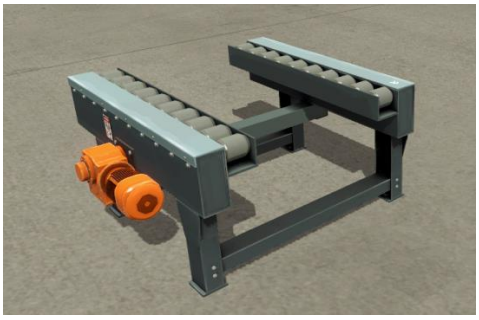

Figure 8. Loading conveyor

E. Load and Unloading Sensor

A *load sensor* triggered when the fleet reaches the edge of the loading conveyor to avoid an item from dropping down it makes the conveyor stop from rolling, shown in Figure 9. The stacker crane moves from the center middle limit to right (forks right), from the reception side where the package is and carries it to its targeted position in racks. The *Unload sensor* triggered when the fleet drops down and usually situated at the center, shown in Figure 10. The Stacker crane Lift down the package from the particular cell onto 55. The stacker crane forks left to the delivery side dispatched for an exit. Unload sensor activated and initiates the movement of the loading conveyor together with roller conveyor on the dispatch side. The action of loading and unloading of pallets into racks has a common command sensor but differs in locating the device, which some use a sensor assisted industrial robots [10]. The *load* and *unload sensor* is just one type of sensor name; the retro-refractive Sensor, only differs in positioning [8].

Retro-refractive Sensor, the mode of sense used in both load and unload of goods. It has both a transmitter and receiver, very narrow beam optics designed to sense reflectors or reflective materials at a long-range. The general designed is for Beam Break sensing, usually used with a red or blue light source. The sensor contains both the light source and the receiving device in one housing. A specific dual-lens system or bifurcated fiber optic light guide launches the transmitted light beam path and the returned light beam path on the same axis. Once a fiber is pointed or aimed at a reflector, the light beam is reflected on a receiving lens or fiber. Sensor position with a prismatic reflector can be tilted by 10 to 15 degrees and still, a strong light beam will return to the receiving lens on precisely the same axis as the original transmitted light beam. To detect the presence or the absence of substances, the light beam path is directed through the detection path so that passing opaque objects interrupt the light beam. When the light beam is cracked or when the intensity of the received light beam is reduced below a threshold level, the sensor responds by switching its output [12].

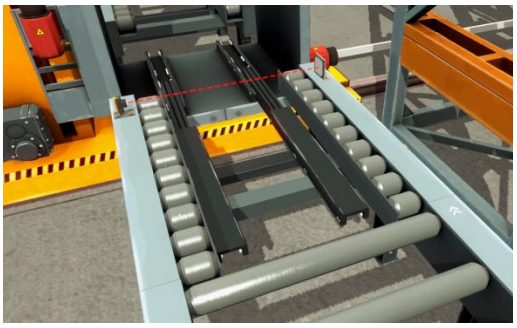

Figure 9. At load sensor- edge position

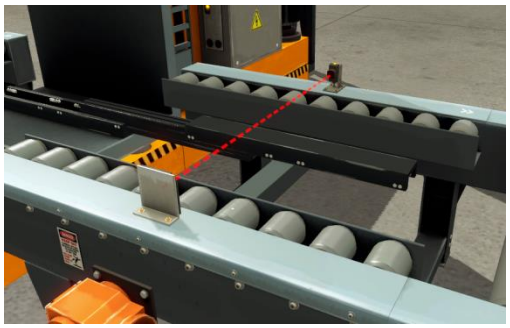

Figure 10. At unload sensor, center position

F. Stacker Crane

Machine crane, this is the fixed position settle crane that only moves in 3 directions, moving X, moving Y and moving Z in receiving to storage and dispatch. Automatic Storage and Retrieval System (AS/RS systems) are designed for automated storage and retrieval of parts and items in manufacturing, distribution, retail, wholesale and warehouses. Stacker Crane programming suited AS/RS in an intelligent warehouse functionality [11]. The welfares of an AS/RS system take account of reduced labor for transporting items into and out of inventory, reduced inventory echelons, more accurate tracking of inventory, and space savings. AS/RS frequently stored more compactly than in systems where items are stored and retrieved manually [5]. Inside iWTS stowing items can be located on trays or hang from bars, which are attached to chains/drives to move up and down. The equipment required for an AS/RS comprises a storage & retrieval machine (SRM) that is used for rapid storage and retrieval of material [12]. SRMs are used to move loads vertically or horizontally, and can also move laterally to place objects in the correct storage location [9].

Figure 11. Stacker crane – forks carry

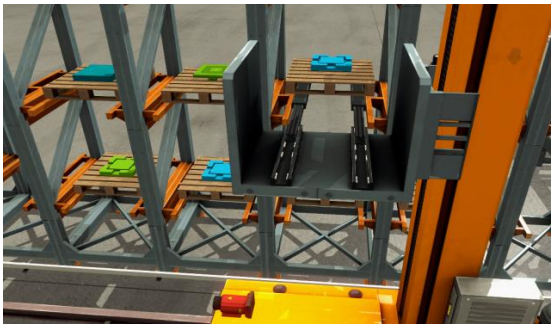

Figure 12. Stacker crane – forks release

G. Racks

This is a master database where the classification of all items is made, number of cabins, rows, and columns. It usually has the storing in and out system, first in first out (FIFO) and first expired first out (FEFO) the parts that manufactured first will be also first to be exported due to the expiration time [6]. Also the special condition for some machine parts that require storage like oiling, unexposed in direct sunlight or come in contact with water. Pallet racks are used throughout industry and distribution facilities for bulk storage of items, save space and maximize the capacity of package storage. Technology is an ever-evolving and ever-influential part in iWTS, smart technologies like AGVs can also position pallet boxes in and out of racks.

Figure 13. Empty shelves – Racks

Figure 14. Racks filled with fleets, items

V. SIMULATION RESULTS

The imitation of these two software starts with the mode of smart connection and design layout. Obtaining the orderly results for executing the system, which requires communication to do it. There are two kinds of monitoring in TIA Portal, Online and Offline. Online; when the ladder diagrams are set for RUN mode and Offline; when writing codes or reset a PLC, known as STOP mode. These two systems have wireless communication that code transferred from TIA Portal to Factory I/O. The TIA Portal is a code bench software and Factory I/O is a project display code in motion. The two software have key embedment frame code which ignites and activates the communication between them. The frame code is called TIA Portal Template, the Projects Note that you must use before the insertion of PLC ladder diagrams to simulate Factory I/O.

The Function block for the communication in the template is preferred to be from the MHJ-PLC Lab Function since it has condition instructions. TIA Portal template project, when presented in a Network it makes the drivers recognize the PLC platform and manage to download or upload the code written in the TIA Portal software. These two platforms are successfully connected only when S7-PLCSIM v13/14/15 is in RUN mode, the Factory I/O will not be able to communicate without S7-PLCSIM. Factory I/O has many PLC acceptable drivers for portal connection, depending on the device you have at the warehouse. Here below in Figure 15, it shows Total Integrated Automation Portal loading completed and ready for pairing with Factory I/O on establishing communication.

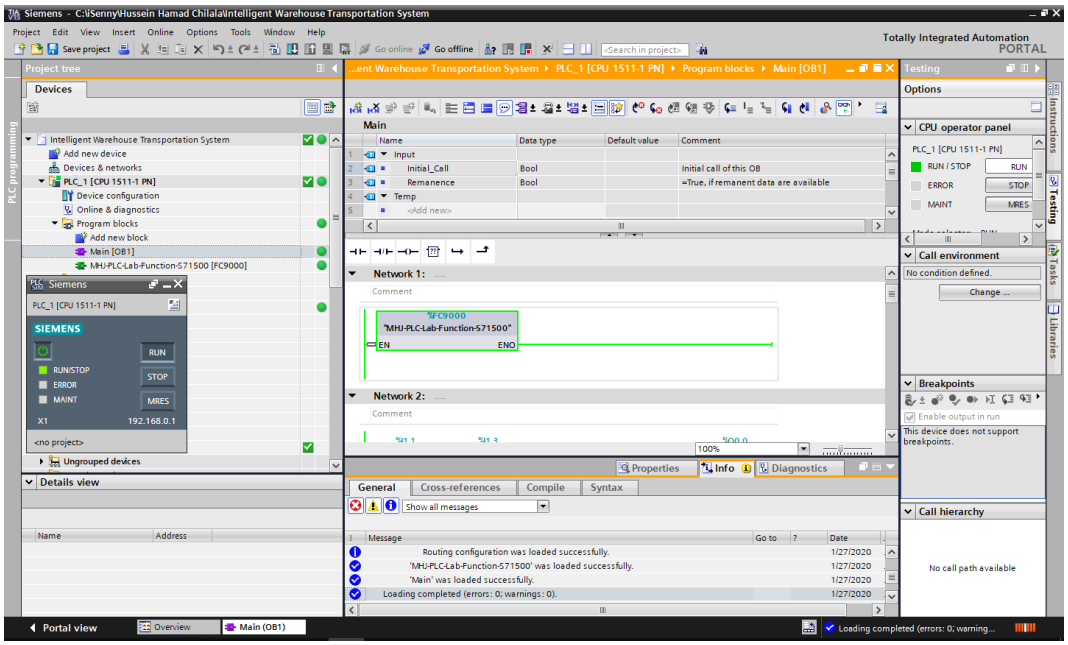

Figure 15. TIA Portal on a Running Mode

Factory I/O comes with the coding platform which is called Control I/O involves coding the warehouse using blocks in arithmetic and Logic gates into functioning. The software version used in this article, TIA Portal v15 and Factory I/O v2.2.3. The Function block is MHJ-PLC Lab Function S7-1500 [FC9000] as a template project ignition for the simulation (IF "condition" THEN statements END_IF). The Factory I/O has lists of drivers that enables the communication from different companies (brand), the drivers (PLC compatible software) available on Factory I/O are;

Advantech	USB 4704 & USB 4750
Allen-Bradley	Logix5000
Allen-Bradley	Micro800
Allen-Bradley	MicroLogix
Allen-Bradley	SLC 5/05
Automgen	Server
Control	I/O
MHJ	Software
Modbus TCP/IP	Client
Modbus TCP/IP	Server
OPC	Client Data Access
Siemens	LOGO!

Siemens S7	200/300/400
Siemens S7	1200/1500
Siemens S7	PLCSIM

There are two kinds of connection when it comes to the TIA Portal to Factory I/O, first if you have an actual PLC device and second if you don't have a device. First, with a device; Open a project and write down a code for the imitation and Go Online to download to a PLC device, while the device is connected on a computer. Second, without a device; Open a project, insert a template note and follow with code writing. Then click a SIMULATION button to Go Online, when PLCSIM is activated open the Factory I/O in drivers select PLCSIM and press connect after load up it will successfully connect.

Figure 16. The connection between TIA Portal and Factory I/O

VI. CONCLUSION

The intelligent warehouse transportation system is impeccable since shelves allow more products to be packed into a tighter space. It also makes stacking and picking more effective by automatically bringing empty shelves over to packers or the right products over to pickers. The process is more accurate and it performing extremely precise in repetitive tasks. The only problem in the iWTS, is replacing a human touch in the warehouse activity. The proposed system has an effective scheduling method, manufacture due to requirement and initialize the sequence of delivering the package accordingly, realizes the intelligent warehouse serves a large demand for quantity and measure the quality of parts.

However; iWTS is far better than having a human walk around to perform tasks manually in the warehouse, the automation system has a small error in perfection. Moreover, there's still a need incapable of some tasks that require fine manipulation or improvisation. Excellent and efficient performance of intelligent warehouse, in how automation can be combined with human labor to increase productivity attaining quality and more importantly a safer working environment. So it is useful to devise ways for a system to collaborate with humans, known as human-robot interaction for more effective operations. The i-WTS carries two sets of genes, smart-s and intelligent-i; 'smart' related to technological and 'intelligent' related to functional. This article innovates current technology but it shows much warehouse functioning, hence it called intelligent WTS.

REFERENCE

[1] E. Zunic, S. Delalic, K. Hodzic, A. Besirevic, and H. Hindija, 'Smart Warehouse Management System Concept with Implementation', in *2018 14th Symposium on Neural Networks and Applications (NEUREL)*, Belgrade, 2018, pp. 1–5, doi: 10.1109/NEUREL.2018.8587004.

[2] V. Mirzabeiki, 'An overview of freight intelligent transportation systems', *IJLSM*, vol. 14, no. 4, p. 473, 2013, doi: 10.1504/IJLSM.2013.052748.

[3] B. Gesing, G. Steinhauer, M. Heck, K. Dierkx, D. Schulz, and S. J. Peterson, 'Artificial Intelligence in Logistics', *Project Management and Editorial Office*, p. 45, 2018.

[4] H. R. Nemati, D. M. Steiger, L. S. Iyer, and R. T. Herschel, 'Knowledge warehouse: an architectural integration of knowledge management, decision support, artificial intelligence and data warehousing', *Decision Support Systems*, vol. 33, no. 2, pp. 143–161, Jun. 2002, doi: 10.1016/S0167-9236(01)00141-5.

[5] B. Li, B. Hou, W. Yu, X. Lu, and C. Yang, 'Applications of artificial intelligence in intelligent manufacturing: a review', *Frontiers Inf Technol Electronic Eng*, vol. 18, no. 1, pp. 86–96, Jan. 2017, doi: 10.1631/FITEE.1601885.

[6] R. Pulungan *et al.*, 'Design of an Intelligent Warehouse Management System', p. 6, 2013.

[7] J. Ploeg, A. C. M. van der Knaap, and D. J. Verburg, 'ATS/AGV-design, implementation and evaluation of a high performance AGV', in *Intelligent Vehicle Symposium, 2002. IEEE*, Versailles, France, 2003, vol. 1, pp. 127–134, doi: 10.1109/IVS.2002.1187940.

[8] G. V. Hicks, 'Industrial Warehousing in the SCAG Region', *Cambridge Systematic, Inc.*, p. 72, Apr. 2018.

[9] K. N. Qureshi and A. H. Abdullah, 'A Survey on Intelligent Transportation Systems', p. 15, 2013.

[10] M. Shneier and R. Bostelman, 'Literature Review of Mobile Robots for Manufacturing', National Institute of Standards and Technology, NIST IR 8022, May 2015.

[11] Y. Liu, Z. Li, Z. Wang, H. Bai, Y. Xing, and P. Zeng, 'Design of the Intelligent Manufacturing Demonstration System based on IoT in the Context of Industry 4.0', *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 252, p. 052001, Jul. 2019, doi: 10.1088/1755-1315/252/5/052001.

[12] A. Ali Yousif and J. Dening, 'Automatic Control for Storage and Retrieval System Based On PLC', *IJAREEIE*, vol. 03, no. 09, pp. 11650–11656, Sep. 2014, doi: 10.15662/ijareeie.2014.0309001.

Hussein Hamad Chilala. "Design of an Intelligent Warehouse Transportation System". *American Journal of Engineering Research (AJER)*, vol. 9(01), 2020, pp 234-241.