FORM 2

THE PATENT ACT 1970 (39 of 1970)
&
The Patents Rules, 2003
COMPLETE SPECIFICATION
(See section 10 and rule 13)

1. TITLE OF THE INVENTION:

IoT and Machine Learning-based Robotic Digital Twin for Object Segregation

2. APPLICANT(S):

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3. PREAMBLE TO THE DESCRIPTION

The following specification particularly describes the invention and the manner in which it is to be performed.

4. DESCRIPTION

TECHNICAL FIELD

[0001] The present disclosure generally relates to a Digital Twin system designated for Robotic-arm based segregation. Most importantly, sorting the object effortlessly and precisely by acquiring control commands from both physical and cyber-physical models.

BACKGROUND

[0002] Object sorting is a tedious job involving a lot of workforce and time. An emblematic manufacturing company may seek to deploy advanced technologies such as the Internet of Things and robotics, but unavoidable constraints restrain and make them rethink in implementing such technologies.

[0003] Adding feedback loops and feedforward loops to the IoT devices, other phases of the IoT lifecycle like design and servicing and preventive management can be improved. The DIGITAL TWIN (DT) is such a concept that bridges the gap and improves the IoT life cycle. Such an effort is put forward in this disclosure.

[0004] Numerous prior arts have attempted to automate robotic sorting systems with multiple prototyping but haven't achieved more desirable features in a single unit for the user.

[0005] Similarly, several prior art documents disclosures have ascertained best devices and practices for robotic arm based sorting systems using several means such as, RFID sensor, IR Sensors, Combinational sensors, camera-based and so on.

[0006] Articles in the prior art 201921012539 titled A SYSTEM EMPLOYING ELECTRICAL DIGITAL TWIN FOR SOLAR PHOTOVOLTAIC POWER PLANT discloses a system based on Electrical Digital Twin for asset management of a Photovoltaic cell-based power plant.

[0007] In the prior art 201941028918, with title DIGITAL TWIN OF A CENTRIFUGAL PUMP, described the invention wherein, whenever an anomaly arises, an alarm is generated from the Programmable Logic Controller (102) and trouble-shooting (replacement of Capacitor of the pump) is done using a Cartesian Arm (107) that can be controlled through Virtual Reality. The Arm utilizes MQTT (106) as its protocol to communicate with the arm

[0008] Another Prior art US20170286572A1 titled Digital twin of twinned physical system by John Erik Hershey et al., disclosed an apparatus may implement a digital twin of a twinned physical system such that one or more sensors to sense values of one or more designated parameters of the twinned physical system. A computer processor may receive data associated with the sensors and, for at least a selected portion of the twinned physical system, monitor a condition of the selected portion of the twinned physical system and/or assess a remaining useful life of the selected portion based at least in part on the sensed values of the one or more designated parameters. A communication port may transmit information associated with a result generated by the computer processor. The one or more sensors may sense values of the one or more designated parameters, and the computer processor may perform the monitoring and/or assessing when the twinned physical system is not operating.

[0009] Similar prior art US11079897B2 – Two-way real-time 3D interactive operations of real-time 3D virtual objects within a real-time 3D virtual world representing the real world discloses a system and method enabling two-way interactive operations of real-time 3D virtual replicas and real objects are described. The system includes a persistent virtual world system comprising a data structure in which at least one real-time 3D virtual replica of a real object is represented, which is stored and computed on a server; at least one corresponding real objects connected to the real-time 3D virtual replica via a network through the persistent virtual world system stored and computed on the server: and at least one user device connected to the real object via the network through the virtual world system stored and computed on the server. Virtually selecting and thereafter effecting changes on the real-time 3D virtual replica results in a real-time corresponding effect on the real object. Likewise, effecting one or more changes on the real object results in a real-time corresponding effect on the real-time 3D virtual replica.

[0010] In Prior art CA2771401C with title Platform health monitoring system, discloses a method and apparatus are present for monitoring a platform. Information from monitoring the platform is received from a sensor network and a number of systems associated with the platform. A plurality of observations is formed from the information. A profile is created from the plurality of observations in which the profile is used to monitor the platform.

[0011] US8705017B2 discloses a system for tracking airborne organisms includes an imager, a backlight source (such as a retroreflective surface) in view of the imager, and a processor configured to analyze one or more images captured by the processor to identify a property of an object.

[0012] An prior art document EP2318804B1 discloses system for detecting intrusion, said system comprising: an illumination source projecting an array of illuminating beams distinguished by beam identifying features, along different optical paths; a detector array comprising elements detecting reflected illumination received in an array of fields of view, said reflected illumination originating from said array of illuminating beams, and said elements using said beam identifying features to determine from which of said illuminating beams said reflected illumination originates; and a signal processing system adapted to detect changes in the reflected illumination levels detected by said elements of said detector array, wherein an increase greater than a first predefined level in said reflected illumination from the field of view associated with an element, provides an indication of an intrusion at the crossing point of that field of view associated with said element, with that optical path whose illuminating beam generates said increase in reflected illumination detected by said element, said optical path being defined by said beam identifying feature of said reflected illumination seen.

[0013] Another prior art document WO 2004/008403 describes a laser-based range finder for use with cameras of an object detecting system.

[0014] Another prior art document US 4065778 shows a focussing apparatus for a camera where the distance to an object is measured via the intersection of a light beam with the camera's field of view.

[0015] Referring to another document CN109071123B, titled discloses invention relates to a Method and device for processing piece goods moving in at least one row in sequence. The invention relates to a method and a device (10) for processing piece goods (2) which are moved in succession in at least one row (1). In this case, the piece goods (2) following in a row (1) without a distance or with a minimum distance are transported as a self-contained formation (F). In this case, at least one transported piece goods (2, 2) is captured in a clamping and/or non-positive and/or positive manner from the self-contained formation (F), spatially separated from the self-contained formation (F), and is placed in a defined relative target position (P) and/or orientation depending on the subsequent piece goods (2).

[0016] US20150369591A1 document titled Optical detection systems and methods of using the same where the invention invention relates generally to the field of optical detection systems and, more particularly, to improved systems and methods for accurately detecting presence in, and/or interference with, an area to be monitored using fiber optics.

[0017] JP5263692B2, presented an invention relates to a laser scan sensor that detects, for example, an intruder into a building site, and in particular, after a warning area is set, a new harmless obstacle is installed in the warning area or a car or the like enters. The present invention relates to a laser scan sensor capable of accurately detecting an intruder that should be detected regardless of the presence of the intruder even when the vehicle is parked.

[0018] In an early document US10535202B2, titled Virtual reality and augmented reality for industrial automation. The invention relates to an industrial visualization system that generates and delivers virtual reality (VR) and augmented reality (AR) presentations of industrial facilities to wearable appliances to facilitate remote or enhanced interaction with automation systems within the facility. VR presentations can comprise three-dimensional (3D) holographic views of a plant facility or a location within a plant facility. The system can selectively render a scaled-down view that renders the facility as a 3D scale model, or as a first-person view that renders the facility as a full-scale rendition that simulates the user's presence on the plant floor. Camera icons rendered in the VR presentation can be selected to switch to a live video stream generated by 360-degree cameras within the plant. The system can also render workflow presentations that guide users through the process of correcting detected maintenance issues.

[0019] In a prior document US10782668B2 by Lingyun Wang et, al. discussed about A system and method is disclosed for development of a control application for a controller of an automation system. The controller receives sensor signals associated with perception of a first real component during an execution of the control application program. Activity of a virtual component, including interaction with the real first component, is simulated, the virtual component being a digital twin of a second real component designed for the work environment and absent in the work environment. Virtual data is produced in response to the simulated activity of the virtual component. A control application module determines parameters for development of the control application program using the sensor signals for the first real component and the virtual data. An AR display signal for the work environment is rendered and displayed based on a digital representation of the virtual data during an execution of the control application program.

[0020] In an early document US7344082B2, titled Automated method of and system for dimensioning objects over a conveyor belt structure by applying contouring tracing, vertice detection, corner point detection, and corner point reduction methods to two-dimensional range data maps of the space above the conveyor belt captured by an amplitude modulated laser scanning beam, disclosed A fully automated package identification and measuring system, in which an omni-directional holographic scanning tunnel is used to read bar codes on packages entering the tunnel, while a package dimensioning subsystem is used to capture information about the package prior to entry into the tunnel. Mathematical models are created on a real-time basis for the geometry of the package and the position of the laser scanning beam used to read the bar code symbol thereon. The mathematical models are analyzed to determine if collected and queued package identification data is spatially and/or temporally correlated with package measurement data using vector-based ray-tracing methods, homogeneous transformations, and object-oriented decision logic so as to enable simultaneous tracking of multiple packages being transported through the scanning tunnel.

[0021] The present invention provides an effective object detection and sorting system based on a mixture of Image processing, Artificial Intelligence and IIOT concepts for a better segregation system.

[0022] The present invention addresses the shortcomings mentioned above of the prior art.

[0023] All publications herein are incorporated by reference to the same extent as if each publication or patent application were specifically and individually indicated to be incorporated by reference. Where a definition or use of a term in an incorporated reference is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies, and the definition of that term in the reference does not apply.

SUMMARY

[0024] The following presents a simplified summary of the disclosure in order to provide a basic understanding of the reader. This summary is not an extensive overview of the disclosure, and it does not identify key/critical elements of the invention or delineate the scope of the invention. Its sole purpose is to present some concepts disclosed herein in a simplified form as a prelude to the more detailed description that is presented later.

[0025] Exemplary embodiments of the present disclosure are directed towards the Industrial IoT and Machine Learning-based object Sorting Device.

[0026] An exemplary object of the present disclosure is directed towards a system that monitors and detects the shape and size of the object.

[0027] Another exemplary object of the present disclosure is directed towards integrating microcontroller 101a with camera 101b mounted on a servo motor-101c to formulate OBJECT IDENTIFICATION DEVICE (OID) 101. Whose primary function is to capture the Video-Image 101b-1 and execute relevant machine learning algorithms to identify the type and quantity of objects.

[0028] Another exemplary object of the present disclosure is OBJECT IDENTIFICATION DEVICE (OID) 102, capable of identifying the type of objects from single-camera 101b whose position changes from horizontal view (HV-020) to vertical view (VV-010).

[0029] An exemplary aspect of the present subject matter is directed towards integrating microcontroller 101a with camera 101b to detect the number of objects placed for sorting by adjusting the camera angle from vertical view (VV-010) to horizontal view (HV-020) with the help of a servo motor 101c.

[0030] An exemplary aspect of the present subject matter is directed towards using Microcontroller 101a to detect object quantity and predict the time and speed required for conveyor movement using a relevant algorithm.

[0031] An exemplary aspect of the present subject matter is directed towards integrating a microcontroller 101a with Speed Measuring Sensor SMS-102b, Speed Regulator Unit SRU-102c and Motorized Conveyor Mechanism MCM-102d to form Smart Conveyor Platform (SCP)-102.

[0032] Another exemplary aspect of the present disclosure is directed towards the integration of microcontroller 101a with Robotic Arm (RA)-103a, which has a 6-Degree of Freedom to form the Sorting Mechanism SM 103.

[0033] Another exemplary aspect of the present disclosure is directed towards the use of appropriate wireless communication channel WCC 105 to connect the cyber-physical models.

[0034] Another exemplary aspect of the present disclosure is directed towards microcontroller 101a, transceiving the data pertaining to all the relevant sensors present in cyber-physical models.

[0035] Another exemplary aspect of the present disclosure is directed towards developing Digital Twin in a digital environment(Computer Program), a replica of the physical models.

[0036] Another exemplary aspect of the present disclosure is directed towards WCC 105 which create bi-directional communication between PM 001 and CPM 002.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] In the following, numerous specific details are set forth to provide a thorough description of various embodiments. Certain embodiments may be practised without these specific details or with some variations in detail. In some instances, certain features are described in less detail so as not to obscure other aspects. The level of detail associated with each of the elements or features should not be construed to qualify the novelty or importance of one feature over the others.

[0038] FIG.1 is a diagram depicting 100 Industrial IoT and Machine Learning-based Digital Twin for Object Segregation, according to an exemplary embodiment of the present disclosure.

[0039] FIG. 2 is a representation of Component Architecture of Object Identification Device-OID 101, according to an exemplary embodiment of the present disclosure.

[0040] FIG. 3 is a representation 102 Component Architecture Of Smart Conveyor Platform (SCP-102) , according to an exemplary embodiment of the present disclosure.

[0041] FIG. 4 is a diagram 400 Process executed in Industrial IoT and Machine Learning-based Digital Twin for Object Segregation, according to an exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0042] It is to be understood that the present disclosure is not limited in its application to the details of construction and the arrangement of components outlined in the following description or illustrated in the drawings. The present disclosure is capable of other embodiments and of being practised or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

[0043] The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms "a" and "an" herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. Further, the use of terms "first," "second," and "third," and the like, herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another.

[0044] Referring to FIG. 1 is a diagram 100 depicting the Industrial IoT and Machine Learning-based Digital Twin for Object Segregation, comprising of Physical Model (PM)-001 and a Cyber-Physical Model (CPM)-002. Wherein Physical Model (PM)-001 constitutes Object Identification Device (OID)-101 mounted on Smart Conveyor Platform (SCP)-102, Robotic Arm (RA)-103a with 6-Degree of Freedom. All the physical components are replicated in a cyber-physical model (CPM)- 002 called Digital-Twin (DT)-104. The status of each element in the physical model PM-001 is updated in the cyber-physical model (CPM)- 002 (Digital-Twin (DT)-104) via a suitable Wireless Communication Channel (WCC)-105. WCC 105 can be a Wifi or a Bluetooth, or Ultra Wide Band communication media and the media of communication is chosen based on the need and circumstances to reduce the data loss and establish a strong bi-directional network between PM 001 and CPM 002.

[0045] Further, the Robotic Arm (RA)-103a with 6-Degree of Freedom integrated with Microcontroller 101a to form the Sorting Mechanism 103, is placed conveniently on the Smart Conveyor Platform (SCP-102), wherein SM-103 executes its relevant job based on the instruction received. The relevant job may be a pick and drop, remove or replace etc., The action of SM-103 is based on the commands received either from the microcontroller 101a or the user through Digital Twin -104. And also the same scenario with the speed of the Smart Conveyor Platform (SCP-102), wherein commands received either from the microcontroller 101a or the user through Digital Twin -104 are realized.

[0046] In accordance with a non-limiting exemplary embodiment of the present subject matter, FIG. 2 is a depiction of the Object Identification Device (OID) 101 capable of identifying the type of object and the number of objects presented for sorting. OID-101 comprises a Video capture enabled Camera sensor in-short camera 101b and an advanced microcontroller 101a. Microcontroller 101a is fed with video images 101b-1, which are captured from the camera 101b and in turn, Microcontroller 101a executes relevant Machine Learning(MLA) and Deep Learning (DLA) algorithms to identify the object type of object 107 on the conveyor 102 and quantity 108 of objects present in the grate.

[0047] Further, camera 101b in Object Identification Device (OID) 101is mounted on a mechanized servo structure 101c to enable the camera to take video images 101b-1 in vertical view (VV-010) and horizontal view (HV-020). A servo motor 101c is placed appropriately to tilt the camera 101b from one axis to another based on the given command. A pile of objects 108 to be sorted is placed any possible holding area parallels to the conveyor 102, and hence camera 101b is moved to horizontal view (HV-020). Similarly, to identify the type of object 107, camera 101b is moved to the vertical view (VV-010) position. The tilt operation takes place for every pile of objects, which means once the count of object operation is done, servo motor 101c changes the angle to VV-010 so that IOD 101 can shift its mode to object identification.

[0048] In accordance with a non-limiting exemplary embodiment of the present subject matter, FIG. 3 depicts the Component Architecture Of the Smart Conveyor Platform (SCP-102). Smart Conveyor Platform (SCP)-102 comprises of Integrated microcontroller 101a with Speed Measuring Sensor SMS-102b, Speed Regulator Unit SRU-102c, Motorized Conveyor Mechanism MCM-102d. Microcontroller 101a measures the speed through Speed Measuring Sensor SMS-102b and updates in its virtual environment DT-104.

[0049] Further, Motorized Conveyor Mechanism MCM-102d consists of a variable speed motor whose speed can be vary based on its input parameter. The input parameters can be altered by the Speed Regulator Unit SRU-102c based on commands received from Integrated microcontroller 101a or its digital counterpart. Microcontroller 101a, based on the pile of objects/count of the objects, decides the necessary speed to be maintained by executing relevant MLA or DLA. Once the time and speed are determined, SRU-102c vary the input parameters, a voltage or current given to MCM 102d.

[0050] In accordance with a non-limiting exemplary embodiment of the present subject matter, FIG. 4 depicts the 400 Process executed in Industrial IoT and Machine Learning-based Digital Twin for Object Segregation. The process starts at step 401, wherein Microcontroller 101a initialises the system and aline the camera 101b in HV-020 by adjusting the servo-mechanism embedded in IOD 101. In step 402, Microcontroller 101a executes relevant MLA and DLA on Video Images 101b-1 to identify the approximate quantity of objects 108 piled up in the storage place.

[0051] Further, in step 403, Microcontroller 101a updates the value in its digital counterpart DT-104 and executes relevant MLA on Video Images 101b-1 to predict the speed 109 at which the conveyor MCM 102c is to be set. The set speed is based on either criterion set by the user through its digital counterpart DT-104 or the predicted outcome of the relevant MLA. In consecutive step 404, Microcontroller 101a updates the speed in DT-104 via WCC 105 and sends the appropriate command to SRU-102c. In step 405, IOD 101 is positioned HV 010 onto the conveyor 102 and start the MCM 102d. In step 406, IOD 101 detects the object by performing relevant MLA and DLA on video images 101b-2 and send the appropriate command to SM 103. In step 407, based on the object, time and speed to sort, SM 103 moves RA 103a to perform the relevant act of sorting. In step 408, microcontroller 101a communicates with DT 104 to update the status and verify for further instructions.

[0052] In another embodiment, the realization of Digital Twin DT-104 is carried in either virtual reality or augmented reality platforms. Wherein the user can visualize the physical model and its components replica by using appropriate hardware and software. The user commands issued via cyber-physical model (DT-104) in virtual reality or augmented reality are transmitted to the physical model through WCC 105. Microcontroller 101a, once received the commands from its counterpart DT 104, starts executing the said commands on its physical components.

5. CLAIMS STATEMENT

We Claim.

1. The Industrial IoT and Machine Learning-based Digital Twin for Object Segregation, comprising of,
   Physical Model (PM)-001 and a Cyber-Physical Model (CPM)-002,
   Wherein Physical Model (PM)-001 consists of Object Identification Device (OID)-101, Smart Conveyor Platform (SCP)-102, Robotic Arm (RA)-103a with 6-Degree of Freedom and Cyber-Physical Model (CPM)-002 is of Digital-Twin (DT)-104; and
   Physical Model (PM)-001 and a Cyber-Physical Model (CPM)-002 communicate via Wireless Communication Channel 105; and
   Object Identification Device (OID)-101capable of capturing the type 1 and quantity of objects through Video-Image 101b-1
   Smart Conveyor Platform (SCP)-102 is capable of adjusting the speed based on the set parameters; and
   Robotic Arm (RA)-103a is capable of sorting the objects based on instructions provided by the user; and
   Wireless communication channel 105 creates a bi-directional communication channel between PM 001 and CPM 002.

2. The device, as claimed in claim 1, Object Identification Device (OID)-101 comprises a Video Camera 101b mounted on servo mechanized structure 101c and an advanced microcontroller 101a. Servo mechanized structure 101c tilts the camera 101b in vertical view (VV-010) and horizontal view (HV-020).

3. The device, as claimed in claim 1, in Object Identification Device (OID)-101 Microcontroller 101a is fed with video images 101b-1, which are captured from the camera 101b and in turn, Microcontroller 101a executes relevant Machine

Learning(MLA) and Deep Learning (DLA) algorithms to identify the object type 107 on the conveyor 102 and quantity 108 of objects present in the grate.

4. The device, as claimed in claim 1, in Object Identification Device (OID)-101 to identify the number of objects 106, camera 101b is moved to horizontal view (HV-020). Similarly, to determine the type of object 107, camera 101b is moved to the vertical view (VV-010) position. The position change command is derived out of the process executed in microcontroller 101a or the user command issued from Digital Twin -104

5. The device, as claimed in claim 1, Smart Conveyor Platform (SCP)-102 comprises of Integrated microcontroller 101a with Speed Measuring Sensor SMS-102b, Speed Regulator Unit SRU-102c, Motorized Conveyor Mechanism MCM-102d.

6. As claimed in claim 1, the device Motorized Conveyor Mechanism MCM-102d consists of a variable speed motor whose speed can be varied by regulating any one of the input parameters. The said parameters can be altered by command derived out of the process executed in microcontroller 101a or the user command issued from Digital Twin -104.

7. The device, as claimed in claim 1, Microcontroller 101a executes relevant MLA and DLA on Video Images 101b-1 to identify the approximate quantity of objects 108 piled up in the storage place. Based on the Quantity 108, Microcontroller 101a sets the speed of the MCM 102d. Set speed of MCM 102d may be derived out of the process executed in microcontroller 101a or the user command issued from Digital Twin -104.

8. The device, as claimed in claim 1, the speed of the Smart Conveyor Platform (SCP-102)can be varied based on commands received either from the process executed in microcontroller 101a or the user through Digital Twin -104 are realized

9. The device, as claimed in claim 1, the Robotic Arm (RA)-103a with 6-Degree of Freedom integrated with Microcontroller 101a to form the Sorting Mechanism 103, is placed conveniently on the Smart Conveyor Platform (SCP-102), wherein SM-103 executes its relevant job based on the instruction received. The appropriate job maybe a pick and drop, remove or replace etc.,The sorting command derived out of the process executed in microcontroller 101a or the user command issued from Digital Twin -104

10. The device, as claimed in clime 1, the realization of Digital Twin DT-104 is carried in either virtual reality or augmented reality platforms. Wherein the user can visualize the physical model and its components replica by using appropriate hardware and software.

6. Date Signature

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ABSTRACT

"**Industrial IoT and Machine Learning-based Digital Twin for Object Segregation**"

Exemplary aspects of the present disclosure are directed towards the Industrial IoT and Machine Learning-based Digital Twin for Object Segregation, comprising of Object Identification Device (OID)-101, Smart Conveyor Platform (SCP)-102, Robotic Arm (RA)-103a with 6-Degree of Freedom, a Digital-Twin (DT)-104 communicated via a suitable Wireless Communication Channel (WCC)-105. Microcontroller-101a integrated with Camera-101b mounted on a servo motor formulates OID-101, capturing the type and quantity of objects through Video-Image 101b-1. Microcontrollers 101a executes appropriate Machine Learning Algorithms 030 assess the type 107 quantity 108 and speed 109 for Conveyor 102. Once Object quantity 108 is established by OID 101 through Video-Images 101b-1, the objects moving on the conveyor mechanism are sorted based on a predefined sorting algorithm or commands received from DT-104. Robotic Arm (RA) 103 sorting process, object-detection, and conveyor speed are updated in real-time Virtual/Augment Reality platform through sensors placed on all embodiments through WCC 105 to Cloud-based Digital-Twin(DT)104. FIG-1