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Live Working of Robots using Cloud Computing Technology

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Abstract

In the current operating modes used in working of live robots in industries, we cannot fulfill the computational power requirements needed by AI highly-precise algorithms. It's also challenging to handle the complex and large working environment, and cannot be used in a situation where a N number of robots are working simultaneously and generating huge data which has to be managed and controlled. In light of these flaws, this study compares and analyses both the operating modes of robots which are used in power grid inspection and working of robots used in industries, and presents an intelligent control technique for managing live working robots using cloud and edge computing module. The challenges that existed in the previous can be solved by deploying distinct components of the deep learning algorithm in cloud computing and edge terminals, the issues with working mode have been resolved. An example of live working robot situation in the substation is investigated. The findings reveal that the proposed intelligent control approach in this paper can meet the requirements. Artificial intelligence(AI), deep learning requires a lot of learning, computing power, and Self-learning, recognition, self-renewal, coordinated neural network control and other highly-precise control algorithm, and it can be used in a scenario with a lot of moving parts or a vast robots working simultaneously which generates large amount of data to be managed and controlled.

Keywords: *Deep learning, Machine learning, complex data, live working robot, intelligently controlled robots, Edge Terminal Technology and Cloud Computing Technology.*

1. Introduction

Live working is a key strategy for reducing outage times and increasing power supply reliability. Manual live working had some issues in the past, such as high operation risk, low accuracy, low work efficiency and high labor intensity. As a result, the industry has conducted a significant amount of study in development of live working robots, as well as having a practical product work, hoping that robots has to be replaced in scenarios of manual work will be realized [1-4].

In the current technologies of robots working live in the power grid is at the application stage of pilot, and it is primarily employed in distribution lines, transmission lines, distribution stations, substations, and other working scenarios. Currently, the operating mode of a live robot is as follows: sensors collects required data for the performance and transfers the data to the industrial local computers [3-6].

A Robot is controlled by an industrial computer that follows a pre-complied program or manual judgment. Semi-autonomous & completely autonomous operation are the two kinds of human-computer interaction. The following issues arise as a result of this type of working mode:

1) The appropriate visual, perceptual, and operating procedures are executed on the industrial control computer. Single chip microcomputer, CPU(Central Processing Unit), ARM(Advanced RISC Machines), and DSP(Digital Signal Processing) are at the core of it. Classical processors can only handle the computational demands of machine learning, traditional image processing, controlling master-slave, coordinated control, multimodal fusion [1]. It can't handle artificial intelligence(AI), machine learning [7-8], deep learning, identification, neural network coordinated control, self-renewal, control model, self-learning and other algorithms which is highly-precise that demand a lot of processing power and complex working scenes is hard to adapt.

2) The number of robots will grow greatly as there is improvement in practical degree of live operating robots [9], which needs both control and management inevitably. At the same time, all real working robots are in a single mode of operation, which can't be applied in a scenario where N number of robots are operating simultaneously and generating vast amounts of data.

3) As a result, in contrast to the single working of live robot with a regular processor, this study develops an intelligent working robot based on edge terminals and cloud computing in the hopes of meeting the computational needs of highly-precise algorithms such as AI, identification, neural network coordinated control, deep learning, self-learning, control model, self-renewal and can be applied to the complex working environment.

2. Analysis & Comparison of live working modes on traditional robots

A. Traditional Live Working Robots

Currently, the semi-autonomous and completely autonomous live working robots employed in substations and overhead wires are the most common. To perform the mission, a semi-autonomous live working robot requires human-computer interaction, as depicted in Fig 1. The completely autonomous live working robots, as illustrated in Fig 2, can execute the job according to the program which is been set. These are the two types of robots working live which depends on industrial computer to analyze & perform necessary operations [13].

Fig. 1. Live working Robot Semi-autonomous

Fig. 2. Live working Robot fully autonomous

B. Existing Robots used in Power Grid Inspection and their Operating Modes

Existing robots used in power grid inspection are classified as transmission line inspection robots, inspection on cable, inspection on substation and inspection on power grid UAV (Unmanned Aerial Vehicle) [8-11], as illustrated in Figure 3. The optical, acoustic, electrical, and other characteristics of power grid information acquired by these four inspection robots is sent to a cloud server for processing and analysis in order to complete the inspection operation [13].

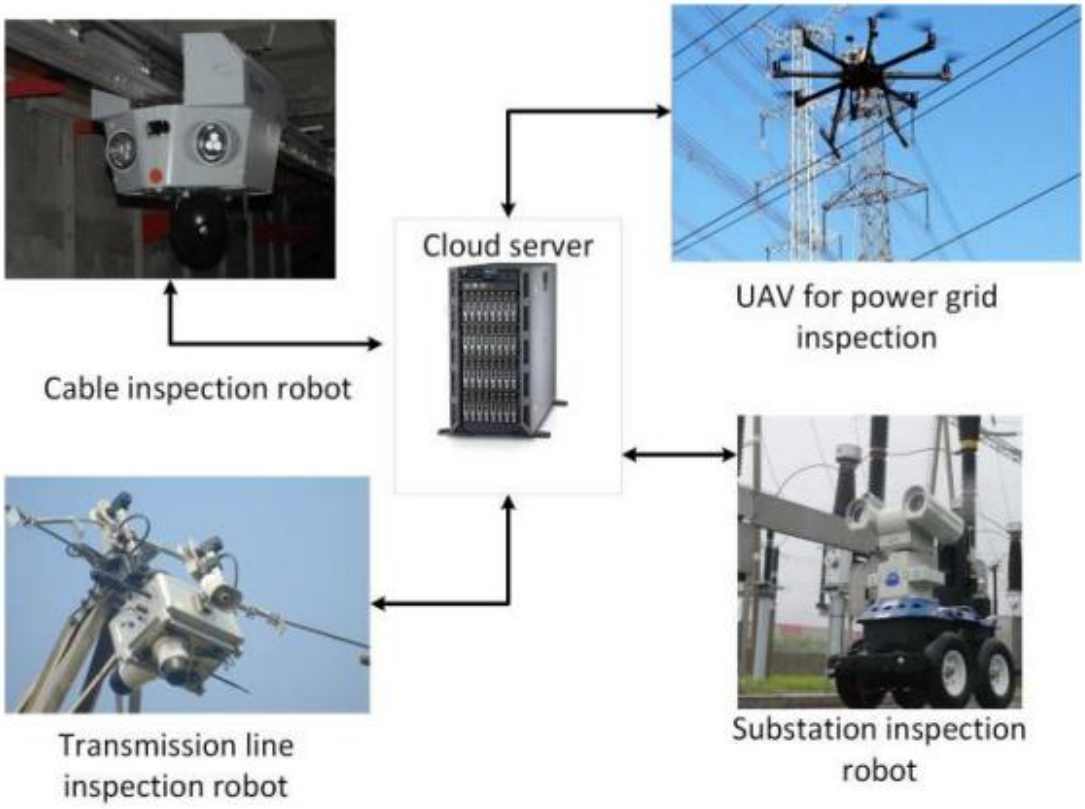

Fig 3. Robots Inspection on Power Grid (existing)

C. Analysis- Conclusion

While comparing both the live operating modes of the existing robots used in inspection on power grid and the working of robot in industries, it is concluded that the robots used for inspection uses a cloud server to process and analyze the data, whereas the intelligently controlled working robots uses a local industrial computer to perform the necessary operations and analysis. If all live working duties are sent to the cloud server, poor signal will occur, transferring the information will be delayed, and work errors will occur. As a result, based on edge module terminals and cloud computing, this study provides a control strategy for real working robots and intelligent management. The AI algorithm is used in the edge module terminal, which performs filtering, data pretreatment, and recognition detection. AI algorithm feature information extraction, training, and other calculation can all be done in the cloud computing.

	Human Interaction	AI	Cloud Server	Edge Terminal	Cloud Computing
Semi-Autonomous robot	✓	×	×	×	×
Fully Autonomous robot	×	✓	×	×	×
Existing power grid inspection robot	×	×	✓	×	×
Live Working robot using Cloud Computing Technology	✓	✓	✓	✓	✓

3. DESIGN AND FLOWCHART OF INTELLIGENT WORKING OF ROBOTS

Intelligent working robots flow chart is based on edge terminals and cloud computing is shown in the Fig 4 , which includes live working robot main modules, information transmission modules, sensor modules, edge terminal modules, and cloud computing modules. Each module's describes the function and data transfer process below.

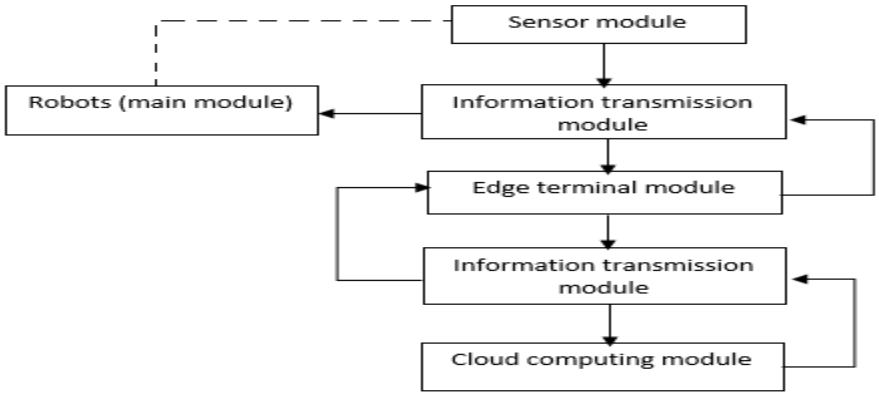

Fig. 4. Flow chart of Intelligent working robots based on edge terminal cloud computing technology.

1. Sensor module

   Sensor detects the environment which is currently working, the operation action, target work, and other data. The information transmission module transmits the data required for intelligent working robots to the edge terminal module. Ultrasonic sensor, Infrared camera, monocular camera, panorama camera, lidar, temperature sensor, depth sensor, humidity sensor, mechanical sensor, photoelectric sensor, and so on are all included in the module.
2. Transmission Module

Transmission module receives the information from the sensor module and transfers it to the edge terminal module, as well as the edge terminal module's filtered information's is sent to the Robots (main module). Wi-Fi communication, 4G/5G communication (keeps changing as technologies develops), information optical cable, Bluetooth module, and other features are included in the module.

3. Edge Terminal Module

Edge terminal module filters the information sent from sensors and from the analyses of the Environment, sends required data to cloud computing module and provides AI algorithm as instructions to the robots, as well as to:

1) Process and filters the information from sensor module for live working robots.

2) Analyzing- Identifying the duties that we wish to assign to a robot or machine. The tasks that must be implemented for each type of robot (if a collection of machines is employed) will be specified separately and sent to cloud computing module.

3) Receives the update of Artificial Intelligence algorithm from cloud computing module and sends it to the Robots as instructions [14].

The module includes edge calculation Neural Network Processor Unit (NPU), Graphics Processing Unit (GPU), Holographic Processing Unit (HPU), Deep Learning Processing Unit (DPU), Field Programmable Gate Array (FPGA), Central Processing Unit (CPU), Application Specific Integrated Circuit (ASIC), Accelerated Processing Unit (APU), Advanced RISC Machines (arm) processor, Digital Signal Processing (DPS), Tensor Processing Unit (TPU), etc.

4. Main Module (Working of live Robot)

To perform the given tasks, the main module (robots) executes the instructions given by the edge terminal module.

Toolbox, Mechanical arm, live working equipment, insulated bucket boom car, robot platform, insulated lifting mechanism, and other items are included in the module.

5. Transmission Module

Transmission module is used to send the edge terminal module's filtered state information and the parameters needed for generating an AI algorithm is been sent to the cloud computing module, as well as the cloud computing module's AI algorithm updated and trained to the edge terminal module. Wi-Fi communication, 4G/5G communication (keeps changing as technologies develops), information optical cable, Bluetooth module, and other features are included in the module.

6. Cloud Computing Module

The AI algorithm and operating system are deployed via the cloud computing module. 1) Receives the filtered information from edge terminal module, as well as the parameters needed for generating an AI algorithm, 2) Filtered information gets visible on the display terminal, 3)The AI algorithm updates the required parameters for training and updating the AI algorithm, and 4) AI algorithm will be implemented. AI algorithms are mostly used for information training, extraction, and other calculation.

In other terms, as the robots connected to a cloud the size of the robot is reduced. Since it has a central storage, learning by the robot and transferring one system to other is easy. It means, when a robot 'A' learn from a person 'B'. When the person 'B' traveled to go other place (like foreign place). Person 'B' has no need to take a robot from his/her own place to another place. Person 'B' can use the other similar type robot by using the access key or password from the cloud server.

Also it is very easy to transfer the learned things by a similar type of robots. So it is an advantage when we implement programs to the cloud.

The cloud computing module, unlike the edge terminal module includes public clouds with display terminals or self-built private clouds that must be configured with high computing power computing cores.
Neural Network Processor Unit (NPU), Graphics Processing Unit (GPU),Tensor Processing Unit (TPU), Holographic Processing Unit (HPU), Accelerated Processing Unit (APU), Deep Learning Processing Unit (DPU), Application Specific Integrated Circuit (ASIC), Field Programmable Gate Array (FPGA), Central Processing Unit (CPU), Advanced RISC Machines (arm) processor, Digital Signal Processing (DPS), etc and so forth.

4. Example of live working robot

1. Basic Database and Application Scenario

The autonomous working of live robot is applied to the substation setting in this study. The AI model of image recognition is trained using 10,000 manually annotated visible photographs. Fig 5 shows a manual note of a visible image of typical power equipment. The study and operation object has been chosen from among 11 common power equipment in substations. Mask Region-Based Convolutional Neural Network **(**R-CNN) deep learning model [12] is designed for object detection in the AI model to recognize and find power device in visible images at the pixel level.

Fig. 5. Manual note of image of typical power equipment

2. Configuration Software and Hardware

Fig 6 depicts the flow chart of an autonomous live working robot applied to a substation scene. The sensor module uses a lidar, monocular visible light camera, and an infrared camera, as indicated in the diagram. The first module of the information transmission system employs an information optical cable and 4G/5G communication. Only 4G/5G communication is used in the second

information transfer module. The main module of a live working robots is equipped with a robot platform, a mechanical arm, live-working tools and a lifting mechanism for insulating.

Software - It is equipped with Ubuntu system, Tensorflow 1.14.0, JetPack 4.3, CUDA 9.2 (Compute Unified Device Architecture) and TensorRT 6.0.1.0

Hardware - The NVIDIA TX2 edge terminal chip is used in the edge terminal module. In the Mask Region-Based Convolutional Neural Network (R-CNN) deep learning model deployed on the edge terminal module, the low-precision neural network FP16 is employed to minimize the amount of calculation.

NVIDIA GPU GTX 2080 TI and highly-precise version of Mask Region-Based Convolutional Neural Network (R-CNN) deep learning model are included in the cloud computing module.

Fig. 6. Flow chart of autonomous working live robots is applied to the substation scene

3. Trial Operation Effect

The visible light pictures obtained by the sensor module in the substation are sent to the edge terminal through the transmission module. The AI program is conducted via the edge terminal, and the usual picture recognition results are displayed in Fig 7. The edge terminal module transmits instruction directions to the (live working robot) main module based on the findings of visual image recognition/object detection.

Through the transmission module, the identified results are sent as the parameters to the cloud computing module, further the AI model is updated.

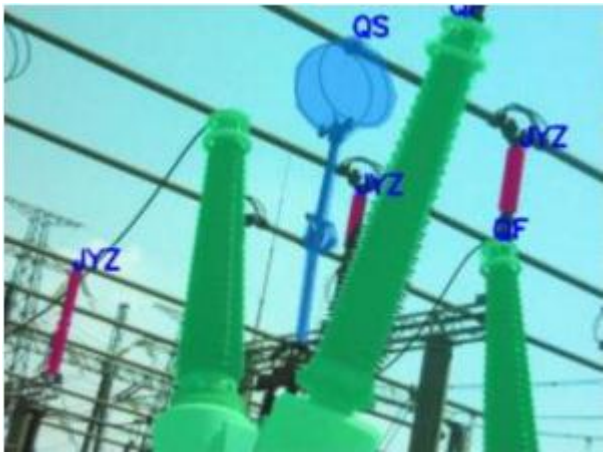

Fig. 7. Object detection /Typical image recognition results.

5. Conclusion

In this study we are analyzing and comparing the different modes in working of Robots which are used in Power grid inspection and in industries. A methodology for controlling the Robots from cloud by using cloud computing technology is proposed which can solve many problems faced in other modes of controlling the robots, which was not capable to handle a very large number of robots working simultaneously generating large amount of data which has to be managed and controlled. The method which is proposed in this paper can fulfill the computational power required for generating algorithms to control the robots using technologies like machine learning, AI neural network coordinated control, deep learning, self-learning, self-renewal, and highly precise algorithms. This method can be applied in scenarios where there is complex work environment or where data is generated in large amount.

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