Application of IoT and Big Data Technology in Digital Testing Platforms

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Abstract. With the advancement of Internet of things and big data technologies, they have been introduced to the traditional experiment testing industry. This paper introduces the composition and functions of digital testing platforms, elaborates the purposes and objectives of these platforms, and analyzes its performance in application in laboratories.

Keywords: Internet of things · big data · detection · application

1 Introduction

Experiment testing is a crucial measure to achieve effective quality control. The accuracy of the testing data and the standardization of the testing process account for an important indicator to evaluate whether a research lab meets the quality standard and the market needs. The traditional lab testing methods rely on the existing quality control codes like ISO17025-2017, GJB9001C-2017, GJB 2725A-2001 [1], formulate internal quality control documents and operation specifications, and achieve recording and source-tracing of lab data by way of transfer of print certificates, manual transcription and archiving. This, however, can no longer meet the needs of research work.

Digital testing platforms, supported by Internet of things (IoT) and big data technologies [2], realize connection of lab devices, real-time monitoring and statistical analysis of the device operation states, which improve the accuracy of lab data acquisition. The platforms establish the standard experiment processes, integrate the experiment procedures into the digital platform, which reduces failures due to manual maloperation and improves the standardization of the experiment operation. The platforms provide sharing access to third parties, which allows transfer of real-time monitored data of testing nodes and statistical information of the experiments, and hence improves utilization efficiency of experiment data.

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2 Purposes of Constructing Digital Testing Platforms

1. by constructing digital testing platforms, we can realize real-time monitoring of lab resources, manage the inventory and utilization of lab resources based on the five elements: manpower, machine, material, method, and environment, which facilitates arrangement of experiment tasks and rational allocation of experiment resources. The digital platform can be used to realize unified management of lab resources, inventory, utilization records, regular checks and the state of the platform.
2. By constructing the digital platforms, we can keep track of the whole process of experiments, integrate the requirements, operation standards, and quality control codes of research projects into the platform, thereby realizing paper-free recording, status confirmation, signature and review of experiment data. On the platform, the experiment data can be stored and archived as per the designed routes, which will facilitate post-experiment data comparison, analysis and source-tracing.
3. The digital platforms can realize full-cycle monitoring and statistics of operation and utilization states of lab devices. The states include in-use, stand-by, limited use, maintenance, and quantitative correction. The platform can also analyze in real time the information about the devices, including failures, power consumption and operation conditions, based on which we can achieve high-efficiency operation of the lab devices, and extend the service life of the devices through proper maintenance measures.

3 Overall Design of the Digital Testing Platform

Through the digital testing platform, we can perform online monitoring of the assets and operation of devices in the lab and achieve a panoramic monitoring mode that integrate the asset maps and device operation conditions, create big data libraries for management of experiment devices, and capture the conditions — management, use, maintenance and repair, of the devices. Meanwhile, the digital tags created by the radio frequency identification (RFID) technique can be used to achieve accurate management of the devices, and through timely analysis of data, we can optimize the allocation of devices, further its potential for productivity, and improve the operation efficiency of the devices.

The digital testing platform is oriented to experiment project management, and realizes online procedure design for links including project proposal (demand input), project review (demand review), and project implementation (establishment of the project team and on-site experiments). It manages the matching of software modules including qualification checks of lab members, review of outsourcing and external coordination, real-time logs of experiments, automatic acquisition of experiment data, and quick generation of experiment reports. By establishing a standard process of experiments, we can solve the problem that the experiment plan and devices cannot be kept track of in real time, allow the researchers to spare more efforts to pre-experiment technical preparation and post-experiment data analysis.

1. The mature bar-code and RFID techniques are used to realize systematic and accurate management of fixed assets, including procurement, reception and borrowing,

transfer, overhaul and disposal of these assets, and with the asset classification statements, the platform can realize consistency of account, card and assets. The auxiliary device and asset management software can be built and connected with the open ports and other information systems in the lab, thereby achieving informatized management of lab assets. With the fundamental management of the devices and back-up (materials) as the objective, the platform covers all links in the full life cycle of the lab assets (type selection, installation, planning, maintenance, repair, analysis and disposal), provides failure repair, prevents failures, and has different maintenance modes including reliability-oriented maintenance and status maintenance. With the planning, submission, review, implementation and analysis of tasks as the main service line, the platform covers procurement, inventory, maintenance, cost accounting and human resource management of the lab.

2. With the platform, we can establish a complete set of work standards and workflow for maintenance and repair of experiment devices, such as the device-based fault management system, repair standards, maintenance and spot-check codes, completeness checks, accuracy detection, state detection, and quantitative verification. With guarantee and management as the core, we can perform statistical analysis of failure and faults of the devices based on the operation, shut-down, defects, faults, accidents, spot-checks and verification records of the device via multiple fault analysis methods to identify the proper maintenance measures.
3. On the platform, we can establish a standard set of experiment workflow modules and requirements for node outputs, including the main business workflow module, the resource management module, the static data module, the mobile solution module and the extra business workflow modules. Among these modules, the main business workflow module is intended to complete experiment tasks, and involves review of requirements and input of the reviews. The resource management module takes the clients, experiment researchers, suppliers, and procurement as the targets of management, and involves such aspects as the client maintenance, staff training, supplier management, sub-contractor management and procurement. The static data module involves data of all existing devices, inventory of production materials and completion status of experiment tasks. The mobile solution module involves steps completed by mobile terminals like ipad, including daily review, data input, input review. The extra business workflow module involves the management of workflows of experiment quoting, contracting and project performance appraisal.
4. On the platform, we can establish a complete system for data transfer, storage and analysis, acquire experiment data and transfer the data in real time, classify the data, summarize the experiment testing projects and testing results. The big data technology is employed to establish the data model for series products, analyze the damage mode and optimization methods, share with the product and supervision administration the experiment workflow control and testing results.

4 Result of Platform Construction

1. The platform realizes automatic monitoring of the lab environment and device operation parameters as well as remote control of the lab devices, keep track of the

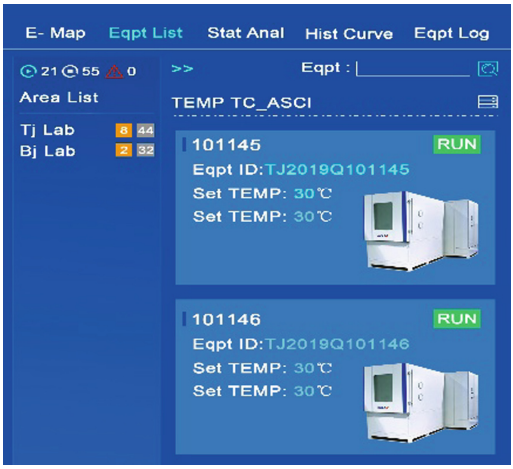

Fig. 1. Equipment monitoring picture

operation conditions and alarming conditions of the lab devices, thereby providing technical support for repair and regular maintenance of the lab devices. This function is achieved through connection of hardware and integration of software; wired and wireless techniques are used for communication, with the wired techniques as the center, and the data are transferred by distributed Internet of things. The spot device monitoring data are collected by the distributed IoT system (Fig. 1).

According to the operation logs of the experiment devices, the platform, as per the results of initial checks and verification results, sets the date for the next round of checks. If the check is not performed before the preset date or the check result fall short of the standard, the device is stopped till it reaches the standard. The fault and alarm records of the experiment device can accurately reflect the location and causes of the fault, guide the researchers to maintain the parts of devices in advance, such as cleaning the filtering system or changing the power source module, to ensure reliable and efficient operation of the device. Besides, the platform can acquire and display data of the lab environment, such as the temperature, humidity and air pressure, in real time, remind the researchers to check whether the environment meets the standard requirements.

With the digital platform, the effective running time of the devices increases, and the platform provides real-time feedback for the operation states of the devices, such as "running", "stand by", and "under maintenance", display the expected time of completion for the running experiment, and the information of the next experiment. With the information provided by the platform, the researchers can better match the experiment tasks and the devices so that the lab can receive more experiment tasks and have a higher production value.

The digital platform can achieve automatic supervision of the lab environment and experiment devices, improve the device management efficiency, enhance digital management of the lab, reduce faults and the failure ratio of the experiment results.

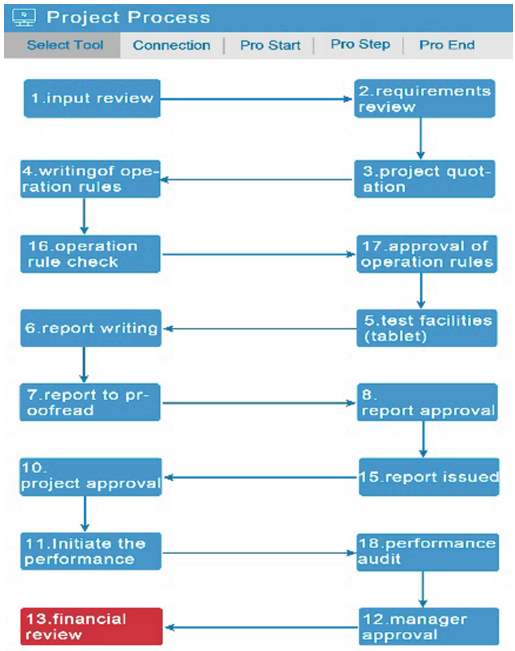

Fig. 2. Test flow chart

2. On the platform, we can keep track of the progress of the experiments, realize automatic acquisition of data of the lab devices, and provide a reliable statistical basis for big data deep mining.

The platform, as per the experiment system requirements, establishes the standard implementation workflow of the experiment testing, sets different access limits for different phases of the testing process, such as the experiment requirement review, testing condition setting, and experiment quality control [3]. The limits include mutual confirmation of experiment conditions, testing state conversion and supervision, testing result confirmation, and review of testing reports. The platform can ensure that all the experiment procedures are performed and recorded under monitoring, thus ensuring the quality of the experiment outputs. Once a problem occurs, we can trace back to where the problem occurs and identify liabilities (Fig. 2).

There are lots of procurement links in the experiment process, such as sub-contracting of experiments, outsourcing of tools, and procurement of consumption materials. The platform can input the information of all suppliers, display the organizations of the suppliers, the review records, the list of procurements, and previous procurement conditions. In the procurement procedure in the experiment process, we can inquiry price and place order directly on the platform, which improves the procurement efficiency without violating any laws or regulations. Meanwhile, as per the annual procurement records, we can evaluate the suppliers as per the times of procurement, the price, the trading quality and the payment efficiency, thereby providing a basis for management of suppliers in

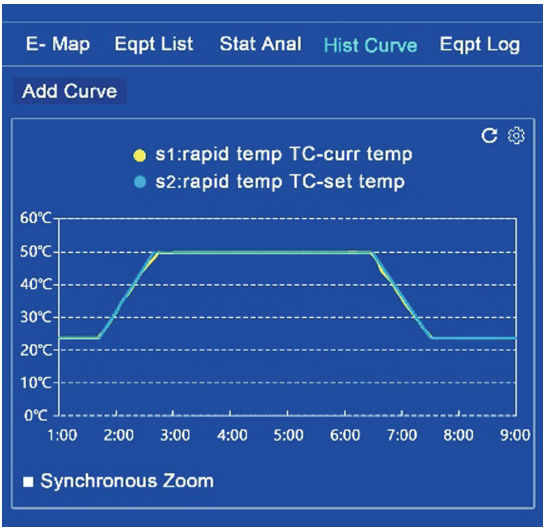

Fig. 3. Diagram of automatic recording of test data

the next year. Moreover, according to the composition of the procurement cost, we can estimate the gross profit of the experiment and the annual gross profit of experiments, thereby providing a basis for budget control of the lab.

In the experiments, there are qualification requirements for workers on different post, such as the project manager and the quality control staff. The staff management module in the platform matches the qualification requirements with the skills of the staff. The platform displays the information for staff on different posts in the lab, the required qualification for experiment operation and the training test results. Only those who have passed the tests and gained the required certificates are allowed to conduct experiments to ensure the quality of subsequent procedures. The operations of the staff in the platform will be recorded and a massive number of experiment data will be generated in the platform. The platform will automatically record and store the data by the data acquisition module. As the formats of the experiment data vary, the data acquisition ports of the platform are normalized to solve the problem that the diversity of the data formats reduces the utilization efficiency of the experiment data [4] (Fig. 3).

3. An experiment data model for series products is established, and the digital platform is used to collect experiment data, the big data technology is used to analyze the quality of products and provide the direction of product design optimization. Meanwhile, the data application module of the platform has such functions as analysis, service, and application.

The data acquisition module of the platform can classify the products by the type of products, the type of experiments and the experiment standard. The big data analysis technology, machine learning and product analysis techniques can be combined to solve actual business problems. For instance, to test whether a controlling device is applicable

to aerospace crafts, it needs to go through the A qualification test; to test whether it is applicable to aviation crafts, it needs to go through the B qualification test, and to test whether it is applicable to marine vessels, it needs to go through the C qualification test. The envelope design of all the qualification tests for the controlling device is performed, the maximum margin design is examined, so that the product can be put to mass production after verification once and meet requirements for different application scenarios, thereby reducing the testing time and workload.

The experiment data in the platform can be used to address faults of experiments. For instance, after the product A goes through an experiment and is found to have structural cracks, we can trace back the problem and find whether the setting of the experiment conditions, the underlying standards and operations meet the quality control system, whether the product constraints meet the client's needs, and compare the results with similar products and experiments the platform has processed in the past. In this way, we can identify whether the problem lies in the design of the structure of the platform or in the experiments. If it is the former, we can optimize the structure based on the experiment data and work with the clients to improve the structure and confirm the outcome by experiments.

When sufficient data are collected, we can formulate the testing standards for a type of product, an industry or a realm based on the data model, develop these standards into a recognized set of standards for groups, enterprises, industries, nations and even the world, so that we can claim authority in the testing domain and allow China to achieve the shift from "made in China" to "created in China".

4. In the platform, we can share access of monitoring to third party administrations like the government and the client's organizations, provide them with the information of the experiment like the experiment progress, the completeness of the experiment, the experiment testing results, and the status of the experiment, including the type of products, the number of experiment projects and the number of reports.

The platform provides access for clients for inquiries and monitoring. The clients can log onto the platform to learn about the completed experiments, including the lab workers for completed projects, the time and results of experiments, and download experiment reports. They can also view information of the undergoing experiments, including the status of the experiments, the devices and expected time for completion. They can also check the capacity of the lab for experiments, test the certification standards, review the testing results and experiment cases. The clients can also consult the staff offline according to their needs (Fig. 4).

The platform provides access for third-party supervision organizations so that they can log onto the platform to check the number of completed experiments, the number of experiment reports and the number of clients.

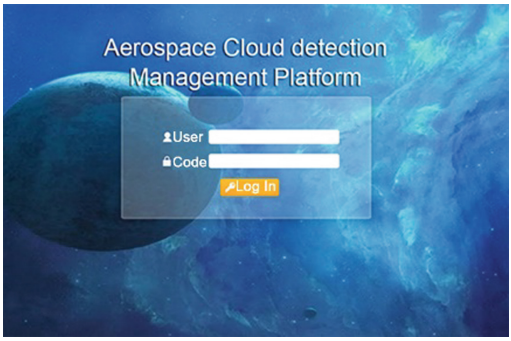

Fig. 4. Third-party login window

5 Application Effect

Through application of the digital testing platform in labs, we can improve the informatized management level of the labs, promote standard operation of the lab, enhance accuracy and timeliness of the experiment data, which allows the labs to provide value-added services including experiment data analysis, and further the collaborations with product research and development organizations. The specific application effect of the platform is as follows.

1. Full life cycle management of experiment devices

The procured experiment devices, after acceptance, are introduced to the digital platform, which monitors the devices in real time and keeps track of the configuration, acceptance and borrowing, quantitative confirmation, fault cause identification, and maintenance of the devices. Meanwhile, by the IoT technology, the platform automatically acquires, transfers and stores data of experiments. It changes the conventional work mode featured by manual recording, shift work, and quality re-checks, improves the accuracy and malleability of the experiment data, and reduces the workload of repetitive work.

2. Standardized management of experiment procedures

According to the quality control documents of the digital platform, the lab management procedures must be designed in the following aspects: experiment testing activities, the responsibilities of lab workers on different posts, regular checks of lab devices, control of external products and services, record control, result quality control, client service and complaints settlement. By introducing different roles and positions like the clients, lab workers, quality control staff, and suppliers into the platform, we can perform remote control on the platform to complete experiment testing projects, provide experiment reports, classify and store experiment data, and keep track of the whole process of the experiment.

3. Experiment cost control

By performing experiments on the digital testing platform, we can analyze the income of the experiment testing project, the direct cost of the experiment, the performance of the lab workers, the experiment management cost. It allows the lab members to analyze the cost and control the budget, optimize the internal management procedures, cut the cost and improve efficiency, and improve the profitability of the lab.

4. Big data mining and analysis

With the statistics from the digital testing platform, we can effectively use the lab resources and devices, and coordinate the tasks between labs. Based on the massive number of experiment data, we can establish the experiment data model for series products and analyze the experiment results of series products, use big data analysis technology to establish a reliable product digital model, and find key parameters that influence the product quality. This will provide the designers with quantitative references and improve the reliability of product design and manufacturing [5]. Continued accumulation and analysis of data will allow us to formulate the experiment testing standards and improve the clout of China across the globe.

5. Third-party quality supervision

The digital testing platform allows the clients to keep track of the testing conditions and subsequent arrangements of their product in real time, and allows them to check the experiment data and compare the data after the testing completes. The third-party supervision administration can provide real-time information supervision, remote checks and monitoring, and statistical analysis of enterprise data.

6 Conclusions

The digital testing platform is a product of combination of experiment testing with Internet of things and big data technologies, which improves the informatized management level of the testing industry, realizes integrated management of lab resources, integration of business operation, analysis and utilization of big data. It enhances the optimized matching between human and devices, realizes real-time monitoring of experiment testing, and provides statistical support for development of labs. Through application of big data technology in experiment data and modelling, the digital platform provides a crucial basis for product designers.

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