Overview and Framework of Quality Service Metrics for Cloud-Based Robotics Platforms

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ABSTRACT

With the rapid development of big data, cloud computing and other technologies, Cloud-based robotic has become one of the key research directions for service robot, such as used in hospitals. A framework and set of metrics for evaluating the quality of service (QOS) of a cloud robotic platform would be greatly facilitate research into and actual practice of service robots. In this paper, a QOS metrics framework of cloud robotic computing is summarized and the research of components and metrics of a cloud robotic platform is reviewed. QOS metrics are organized into software, network, and robotic services. By summarizing and analyzing the above three groups of metrics, a QOS framework or index system is proposed. Finally, future research towards open source and standardization of components of robotic cloud platform is discussed.

INDEX TERMS

Service robot, cloud robotic platform, quality of service, software, network, metrics framework.

I. INTRODUCTION

In the fourth industrial revolution, robotic technology has played an important role. In 2010, Professor Kuffner of Carnegie Mellon University proposed the concept of “cloud robot”, which combines robotics with cloud computing, and unloads complex computing functions of robot such as data processing, planning, decision-making and cooperation to cloud platform. robots body only needs to be equipped with simple network equipment and basic sensors can complete complex tasks [1]–[3]. With the in-depth development of Internet technology, service robot can connect to cloud platform to select and invoke algorithm from cloud platform. Cloud robotic platform is not only an interactive platform, but also a cloud service platform for data transmission with robots. So how to evaluate a QOS of cloud robotic platform is a challenging task.

At present, many experts and scholars have studied software QoS evaluation, network QoS evaluation and service robot related function QoS evaluation. Through the above three aspects, this paper is committed to establish a QOS metrics framework of cloud robotic platform. Firstly, the QOS of software in cloud platform should be tested; secondly, the QOS of network will also affect interaction ability in cloud platform; in addition, a robot will directly feedback effect of service, and its own QOS will be more intuitive. However, realization of grasping by service robot is limited by amount of data transmission, calculation speed, timeliness, etc., which cannot be carried out through the cloud platform, and is more suitable for its own terminal. Therefore, this paper starts with software QOS, summarizes the QOS metrics in software in all aspects, and finds out evaluation metrics suitable for cloud platform. Furthermore, the cloud platform carries a large number of data stream transmission through network, and needs to summarize a corresponding QoS metrics in network for evaluation. In this paper, the QOS metrics of robots are similar to each other, and most of them can be classified into different metrics. After summarizing and analyzing the above three methods, a scientific QOS metrics framework of cloud robotic platform is obtained, and a future direction of the framework is prospected. Figure 1 shows content of the metrics framework to be discussed, and detailed description of the metrics will be expanded in the following sections.

II. QOS OF METRICS IN SOFTWARE

In view of current various QoS of software in index systems [4], considering performance requirements of cloud robotic platform in terms of system security, operation, read-write speed and request time, as well as two aspects...
of functional integrity and business processing. This paper
analyses the main QoS of software related features in
ISO / IEC 25010:2011, discusses evaluation of six groups
of metrics, including functionality, reliability, availability,
efficiency, maintainability and portability, summarizes the
software metrics of cloud robotic platform.

A. FUNCTIONALITY EVALUATION METRICS
The capability of the software product to provide functions
which meet stated and implied needs when the software is
used under specified conditions. It includes four groups of
metrics, which are suitability, accuracy, interoperability and
security. Suitability evaluation is more inclined to subjective
evaluation of users; accuracy refers to accurate frequency
of events encountered, and there are many prediction mod-
els [5], [6] that can be used for evaluation; Interoperability
reflects interaction ability between software and other sys-
tems; security is undoubtedly a key issue to be considered.
The latter three parameters are more suitable for performance
evaluation of software.

B. RELIABILITY EVALUATION METRICS
Reliability can reflect requirements, design and implementa-
tion errors in software, and has a great impact on perform-
ance. It includes three groups of metrics: maturity, fault
tolerance and recoverability. Maturity reflects scientific and
standard degree of software and whether there are rules for
management; fault tolerance reflects the ability of software
detection and correction; recoverability refers to the ability to
recover process and data in case of software failure; Maturity
depends on rigor in the software design process, while the
other two groups of metrics can be evaluated by computer
simulation of major accident simulation and other operations
Estimate.

C. USABILITY EVALUATION METRICS
It refers to usage of different users when they operate soft-
ware independently or without external help. The metrics
includes learnability, operability and understandability. The
contents involved are interface design, operation guidelines
and other aspects, which have nothing to do with perfor-
ance. Therefore, this paper does not include them in scope
of research.

D. EFFICIENCY EVALUATION METRICS
For software, the efficiency metrics can be expressed by time
and resource utilization, which is the key to reflect the QoS
of software. From macro level, we can evaluate response time
of request, and at micro level, we can evaluate efficiency
through the use of resources such as read-write performance
and memory.

E. MAINTAINABILITY EVALUATION METRICS
At present, existing software maintainability metrics such as
[7] are selected to analyze the main influential metrics,
including analyzability, changeability, stability and testabil-
ity. Analyzability and changeability mainly depend on sub-
jective evaluation of developers; stability refers to impact of
software requirements and code changes on software system;
testability refers to difficulty and workload of software sys-
ystem testing. The latter two are more suitable for software
independent evaluation.

F. PORTABILITY EVALUATION METRICS
Portability refers to a group of attributes related to the run-
ning ability of software in different environments, including
conformance, installability, adaptability and replaceability.
However, it mainly involves installation and running environ-
ment of software, which has little to do with research content
of this paper, so it is not discussed.

It can be seen that among the QoS metrics in software, some of characteristic metrics among the four groups of met-
crics of functionality, reliability, efficiency and maintainability
have a greater impact on performance of the cloud robotic
platform, because evaluation requirements of the cloud plat-
form are automatic, and human intervention operation pro-
cess is minimized, while performance aspect of other groups
of metrics is relatively small and subjective evaluation Price
method to evaluate. Therefore, the metrics framework of
cloud platform in this paper focuses on the above four types
of QoS metrics in software.

III. QoS METRICS IN NETWORK
With increasing number of Web services published, it is dif-
cult to determine whether selected service has enough QoS
even if it finds services that meet functional requirements
[8]. There are some researches on network QoS evaluation
[9]–[12], most of which rely on user evaluation. At present,
there are different definitions for division of QoS metrics
in network, such as ITU-T [13], [14], IETF [15], [16]. This
paper mainly explores service robots and cloud platform
can maintain a stable and reliable connection state and data
transmission ability, including QoS metrics in network as reliability, efficiency and security.

A. RELIABILITY EVALUATION METRICS
It refers to ability of network services to work normally. Generally speaking, the reliability of network can be analyzed by existing models, such as Nelson model [17], Monte Carlo method [18], etc. And it is usually based on real-time monitoring or web server logs [19], [20]. In this paper, the following three aspects will be discussed as the metrics evaluation basis to measure the network reliability.

1) FAILURE RATE
The types of network exceptions are complex and numerous, such as request error(400), service unavailable(503), etc. In [9], the response data size, failure message and other data are processed to obtain failure probability matrix, and then network failure rate is calculated. An idea proposed in [21] is to use past failure data of similar users to predict web service failure probability of current users. There are also some methods to predict the failure probability of Web services using different composition structures. Considering that there are a large number of users and manufacturers in the cloud platform, it is necessary to calculate the network failure of these users, so as to improve the QOS.

2) MEANTIME BETWEEN FAILURES
Mean time between failures (MTBF) refers to average time between failures of the network. Xuetao Tian [22] and others proposed a web service testing method based on log analysis, taking MTBF as the reliability evaluation metrics with server crash as core. In reference [23], the formula of mean time between failures and the reliability function are given. Compared with other models, the number of user sessions and failed sessions is closer to actual value. The MTBF can help to predict damage degree of the cloud robotic platform.

3) FAULT TOLERANCE
It refers to the ability to maintain certain unique properties of the network when the network fails. Many scholars have proposed fault-tolerant strategies for Web Services [24], [25]. There are many businesses and frequent data transmission in the cloud platform, so continuous evaluation is needed to improve fault tolerance and reduce error rate.

B. EFFICIENCY EVALUATION METRICS
The evaluation methods of network efficiency are mainly load test, strength test and stress test [26]. In [27], they are divided into five different levels for testing, and overall performance chart is obtained through statistical model. This paper considers a situation when a large number of service robots are connected to the cloud platform. In order to make web performance meet requirements of normal operation of the cloud platform, the following four groups of metrics are selected as evaluation basis.

1) RESPONSE TIME
The delay between request and operation completion is one of the most important metrics in Web services. In [26], web server is configured to use fixed threads to process concurrent user requests, and the relationship between load and response time is depicted. When load reaches a certain level and continues to increase, growth rate of response time will increase rapidly. Reducing response time of network means improvement of network efficiency, and response time is also the most intuitive metrics to reflect efficiency of cloud platform.
2) JITTER
Network jitter refers to change degree of packet delay. The smaller the value, the more stable network quality. For the current cloud platform using distributed cluster, network communication between each other is very frequent, and data flow will be larger, so it is necessary to maintain good network stability.

3) THROUGHPUT
Generally, it is calculated by the amount of data passing through network per-unit time, which directly affects network efficiency due to limitation of bandwidth or network rated rate. Throughput determines maximum transmission speed of network, so it is regarded as one of the important metrics of efficiency evaluation.

4) PACKET LOSS RATE
It refers to the ratio of lost packets to transmitted data group. If packet loss rate is too high, transmission speed will be reduced and resources will be wasted.

The efficiency of network involves all aspects of the cloud robotic platform operation process, which needs to be taken as the key research content.

C. SECURITY EVALUATION METRICS
Network security evaluation has become a very important research content [28]. Network security evaluation is to identify assets and vulnerabilities in the network system, effectively evaluate possibility of their utilization and consequences, and put forward reasonable security strategies and protective measures [29]. This paper discusses the following contents:

1) NUMBER OF VULNERABILITIES
Usually, web application vulnerability detection tools such as Paros proxy [30] are used to send request information to server. With help of automation tools, thousands of security checks can be completed in a shorter time. Considering that data security of cloud platform is very important, the results of Web vulnerability scanning can be used as main security standard, and vulnerability scanning methods such as pen-test are carried out regularly to evaluate network security.

2) THE CAPABILITY OF PASSWORD PROTECTION
The cloud platform retains a lot of manufacturer information and historical data of service robots. Therefore, it is necessary to pay attention to and protect its security during use of the cloud platform. Password is the simplest way to determine identity of a cloud platform visitor. In [31], a method of using session identification to ensure password transmission security was proposed and its feasibility was verified, but its effect was not tested under large-scale users. There are also security mechanisms such as “strong password” [32], “additional code” [33] and dynamic password, which can enhance security of passwords. In the cloud platform, password is the last barrier for users to enter system, and its security should be highly valued.

3) THE CAPABILITY OF NETWORK ATTACK PREVENTION
In addition to these network attacks. There are also network attacks such as denial of service attack (DoS) [34] or distributed denial of service attack (DDoS) [35], although they will not cause data leakage, they will easily cause downtime by continuously occupying system resources. Therefore, we should pay attention to this aspect of evaluation in daily maintenance of network security to ensure normal operation of cloud platform in face of network attacks.

Any web application should consider performance of network in process of using, so the above groups of metrics are included in the metrics system of cloud platform.

IV. QOS METRICS IN SERVICE ROBOT
Service robots assist human beings, typically by performing a job that is dirty, dull, distant, dangerous or repetitive, including household chores. They typically are autonomous and/or operated by a built-in control system, with manual override options. As a new field of robot industry, service robot are combined with new formats and modes of mobile Internet. The final service object of cloud robotic platform is robot, so we should summarize the QoS evaluation metrics of service robot suitable for cloud platform. In this paper, the function of service robot is summarized into four aspects: mobile navigation, image recognition, speech recognition and Grasping.

A. MOBILE NAVIGATION
The key of mobile robot evaluation is to test robot’s ability of autonomous navigation and scheduled task without human intervention

1) THE CAPABILITY OF POSITIONING
For example, iterative closest point (ICP) [36] is one of the most commonly used location recognition methods, which allows a little delay in positioning and has a large amount of calculation, so it can calculate location information on the cloud platform.
2) PATH PLANNING AND TRACKING PERFORMANCE

Path planning and path tracking are called navigation, it refers to the process of determining and maintaining route from current position to target location, which requires a complete and qualified navigation algorithm. Compared with the cloud platform, it is more difficult for robots to realize complex operation of path planning, and it takes longer time; but for path tracking, if it is carried out by the cloud platform, there are high requirements for network quality in real-time transmission and reception of a large amount of data, and conditions are more stringent, so it is more convenient to carry out path planning in robot computer terminal.

3) EFFICIENCY

Efficiency can be evaluated according to the path and time it takes, but it is not limited to some robots. For example, the efficiency of a cleaning robot is shown as less repeated paths under high coverage rate [37]. Joon SEOP Oh et al. Used method Based on Distance Transformation to evaluate the efficiency of a cleaning robot only using sensor data [38]. It can be seen that the evaluation standard of mobile navigation efficiency is not single, cloud platform should continue to expand algorithm to evaluate.

4) OBSTACLE DETECTION

The service robot needs to judge road condition in moving process. For example, a performance evaluation method of mobile robot environment recognition proposed by HyunA Kim et al. Uses Speeded-Up Robust Features (SURF) algorithm to realize structure environment matching, and calculates recognition rate and average recognition time [39].

Considering that non-static obstacles and emergencies will also be encountered in process of robot movement, response time of robot may be too long due to the delay of cloud platform processing, which is easy to cause accidents. It is more appropriate to deal with it through some mechanisms of robot.

Because there are too many kinds of service robots with mobile performance, it is not easy to focus on evaluation according to each functional characteristics. Therefore, this paper considers the positioning ability, path planning performance and efficiency of service robot mobile navigation as the key evaluation metrics of cloud platform.

B. SPECIFIC TARGET RECOGNITION

In view of a fact that most service robots have recognition function to realize recognition of specific targets, such as judging user’s intention through gestures, it is necessary to evaluate whether service robots have ability of efficient and accurate visual perception to improve service level of robots. The main problems can be divided into two aspects: segmentation and recognition in image.

Earlier, some scholars [40]–[43] studied on method of simultaneous segmentation and gesture recognition, but with change of time and technology, the performance needs to be improved. In [44], a gesture recognition method based on bof-surf support vector machine is proposed. Compared with average recognition time and average recognition rate of the other two algorithms, it shows that it has higher accuracy and shorter recognition time. In [45], a method for face detection and recognition in real-time environment is proposed, so that monitoring robot can track people and calculate the average recognition rate. After the robot completes image acquisition, it can be transferred to the cloud platform to call relevant algorithm for recognition, and it is convenient for evaluation.

C. SPEECH RECOGNITION

With continuous improvement of intelligent service robot, speech recognition function of service robot is also an important part of it. After speech signal is processed and analyzed, content is recognized and response result is output [46]. It can be evaluated by the following metrics.

1) RECOGNITION RATE

It generally refers to accuracy of text conversion of speech signals. Yuanyuan Han [47] et al. Used Nao robot speech recognition module to call API for speech recognition performance evaluation, and evaluated accuracy of Chinese word segmentation and success rate of command sentence recognition. The training set with noise suppression
will be evaluated in [48], and speech recognition ability of the service robot in noisy environment is explored. The robot can transmit received speech signal to the cloud platform for recognition. The cloud platform can evaluate recognition rate according to recognition results of a certain scale, and there is no need to configure a speech recognition system for each robot.

2) THE CAPABILITY OF SOUND SOURCE ORIENTATION
It is used to evaluate robot’s judgment of sound source direction. For example, Jorge Dá Vila CHACón [49] and others have proposed a method to improve an automatic speech recognition system. Part of the method focuses on finding the best sound source direction, and obtains positioning error of the robot facing sound source direction. However, this performance has little effect on final recognition result, and it is more convenient to use the robot’s equipment, so it is not considered.

3) CLASSIFICATION ACCURACY
With the development of technology, voice recognition capability in robots can not only stay in completion of text conversion. In [50], in order to improve speech recognition performance of the service robot in the home environment, a speech enhancement method was proposed, which has a good accuracy in division of age and gender. The results of speech emotion recognition of social robots are evaluated in [51], and average classification accuracy of five different emotions is obtained. In process of recognition, the service robot further classifies sound to further refine information and make evaluation more targeted.

4) SIGNAL DISTORTION
It refers to deviation degree between signal and original signal in transmission process. In [52], mitsuharu Matsumoto et al. carried out research on robot hearing, evaluated distortion degree of target signal after noise reduction, and expressed it through images. In [53], Ryu Takeda et al. proposed a multi-channel semi blind ICA for sound source separation. Compared with the previous methods, signal distortion after speech separation and reverberation separation is higher. The reception of signals is carried out by service robot’s own equipment, and quality of the signal transmitted to the cloud platform has been more or less affected. Therefore, performance of the equipment should be considered in the aspect of metrics.

It can be seen that the process of speech recognition is more convenient to be handled by the cloud platform, and metrics such as recognition rate and classification accuracy can be quantified and counted through the cloud robotic platform.

D. GRASPING
Good autonomous grasping ability is premise for robot to acquire and transport target object. Grasping involves three main aspects: detection, planning and control [54]. Target detection and planning are mentioned in previous sections. This section mainly discusses control of grasping performance.

Guo et al. [55] and others conducted performance evaluation experiments on robot gripper, and evaluated force between object to be grasped and gripper, and obtained relationship between the clamping force and the friction force to evaluate performance of the grasping force of the gripper, as well as damage of object capturing in the experiment. Nguyen et al. [56] and others evaluated performance of a robot arm, calculated angle of arm through inverse kinematics equation, drew error histogram, and tested the wrist, arm and other angles of the robot manipulator, as well as position error and jitter. It can be seen that control performance of the robot
arm can be analyzed from the grasping force and accuracy. If the robot arm is implemented in the cloud platform, a lot of calculation will be involved in the process of constantly adjusting the optimal force and angle, which is easy to cause network congestion and waste of resources. Therefore, both of them are not suitable for processing and testing on cloud platform. It is more appropriate for robot computer terminal to set fixed parameters according to the service items of the grabbing robot. Therefore, the metrics framework in this paper does not take the grasping performance into account.

V. QOS OF METRICS FRAMEWORK OF CLOUD ROBOTIC PLATFORM

In this paper, around the business of cloud platform and related service robots, the evaluation metrics suitable for QOS of cloud robotic platform are refined and processed, and the final metrics framework diagram is formed. The system is composed of mobile navigation, specific target recognition, speech recognition and basic service ability. The basic service ability is public part of the first three functional metrics, which are integrated into the first three parts and will not be introduced separately.

A. MOBILE NAVIGATION

Nowadays, most service robots are used for indoor activities, and usually use advanced technologies such as laser vision navigation. This paper describes the business process of indoor mobile service robots. After the robot is started, it is necessary to determine its own location before planning mobile route. Generally, it is carried out in a known map environment. If it is in an unknown environment, such as the first use of sweeping robot, it is necessary for the robot to gradually draw map of surrounding area during moving process, and store the complete map in the robot computer terminal for use. After that, the service robot will move destination and track path according to proposed route, and make corresponding temporary adjustment according to obstacles encountered in actual movement process, and the mobile navigation operation is completed when it reaches designated position smoothly.

Its business process metrics can be divided into positioning, path planning, path tracking and obstacle detection capabilities. Path tracking and obstacle detection are required to achieve “zero delay” as far as possible, which can only be completed by the robot computer terminals and sensors. Location and path planning not only needs to call the matching algorithm, but also requires the cloud platform to have strong computing power, as well as the stability and reliability of the framework in service process. Even if there is a failure, if you can quickly repair and restore the data by switching standby server, and continue planning according to original schedule, the impact can be minimized and node can be saved purpose of approximate data operation. Therefore, response time, throughput, stability and recoverability are included to evaluate the QOS of cloud platform. When algorithm execution, interface is required to perform corresponding function operation and data interaction normally, and the interoperability metrics is introduced. Considering misjudgment of operation, the cloud platform should timely monitor and deal with data outliers, and introduce fault
tolerance metrics. All kinds of algorithms and functions need to be simulated and the testability metrics should be included in the framework. The selected metrics are described in detail below:

1) THE CAPABILITY OF POSITIONING
Different from path tracking, which requires a lot of data calculation, such as robot uses this positioning technology based on trajectory calculation in cloud platform, it can calculate specific position information only by obtaining distance traveled by the service robot in unit time interval and change of the robot’s heading in this period of time. By analyzing and locating initial position of the robot, the cloud platform constantly updates its latest position in the process of serving the robot movement, so as to monitor and assist the proofreading work.

2) THE CAPABILITY OF PATH PLANNING
In the cloud platform, at least two levels of requirements should be considered. One is global path planning, which refers to complete path planning from starting position to end point; the other is local path planning. For example, when original route cannot be moved due to obstacles and other reasons, local adjustment is required. In addition, considering particularity of sweeping robot and other functions, cloud platform also needs to have additional planning algorithm to clean effectively and as much as possible. Therefore, in order to better complete the path planning task of service robots, cloud platform needs to have a variety of path planning algorithms to meet the needs of all kinds of mobile robots.

3) RESPONSE TIME
Response time is the most intuitive metric of service efficiency. Cloud platform can not only evaluate complete service process and data transmission time efficiency of mobile navigation, but also make targeted evaluation on specific steps such as positioning and path planning. Cloud platform can judge the overall efficiency of the framework according to the evaluation results.

4) THROUGHPUT
Frequent service requests require cloud platform to have a high throughput in order to process efficiently. For example, the robot path planning process needs to be simulated many times, and a lot of calculation is needed before the best traveling path can be determined. High throughput means high processing capacity, which determines processing speed.

5) STABILITY
As a large-scale system, cloud platform has a large number of users. It is open to use almost any time, and there are usually a large number of robotic access. It is necessary to ensure stability and security of the use at all times, and no downtime is allowed. In order to ensure continuous and uninterrupted service, the framework and network must be stable and reliable.

6) RECOVERABILITY
It refers to data recovery effect of the cloud platform for the robot with short interruption of service, and ability to maintain service progress. If mobile robot loses connection with the cloud platform in the path planning state for a short time, when service robot reconnects within specified time, the cloud platform can continue the path planning operation according to the original progress to assist the robot to complete its functions.

7) INTEROPERABILITY
It refers to the ability of cloud platform to call algorithm interface and share data with service robot. In the process of positioning and path planning, mobile robot needs to transmit data with cloud platform, and cloud platform also needs to call algorithm of corresponding function through interface.

8) FAULT TOLERANCE
It refers to the cloud platform to review and recommend algorithms and freeze operations according to detection of abnormal data or dangerous operations. If the cloud platform calls algorithm after analysis of the service robot, because of similar properties of some robots, the algorithm that does not fully meet its function is adopted. At this time, the cloud platform can select a more accurate algorithm according to abnormal value of data in the operation process.

9) TESTABILITY
It refers to the ability of cloud platform to evaluate its functions and algorithms. The cloud platform needs to simulate and evaluate newly added or modified functions and algorithms, evaluate its performance and accuracy, and reach a certain qualified rate before it can be formally put into use.

B. SPECIFIC TARGET RECOGNITION
The service robot digitizes image by sampling scanning equipment. After collecting image that needs to be recognized, it should be encoded and compressed to facilitate fast transmission and storage. The above functions can only be realized by the service robot computer terminal and equipment. It is inevitable that image will be blurred due to noise, motion, light and other reasons when obtaining the image, and quality of the image will be more or less degraded in the process of image acquisition, transmission and replication. In order to make main hierarchical structure of clearer image, image restoration and enhancement should be carried out. In addition, the image should be further transformed, smoothed and sharpened. Make image outline more obvious. The above operation steps to improve image quality can be collectively referred to as low-level image processing, and the cloud platform can call algorithm to complete the service. Then the processed image is segmented and effective part is extracted for recognition. If the previous processing is appropriate and appropriate segmentation algorithm is selected, segmentation accuracy will be higher. After that, feature extraction of the image is processed, compared with the image in database or text information in the image is
recognized, and the recognition operation is completed and feedback the result is carried out.

Its business process metrics are divided into four parts, image acquisition ability, low-level image processing ability, image segmentation ability and image recognition accuracy. Image acquisition and processing can only be carried out by camera tools and terminals equipped with the service robot. Low level image processing, image segmentation and image recognition can be completed through the cloud platform. The cloud platform is also required to have the corresponding algorithm to realize the function. The efficiency in the recognition process, the stability of the cloud platform, the ability to call the algorithm through interface, the test simulation and fault tolerance ability can produce the final result of recognition the metric of response time, throughput, stability, interoperability, testability, fault tolerance, Network attack prevention capability.

The cloud platform should seek the algorithm that meets its attribute requirements in terms of algorithm service provision and complete the processing as soon as possible.

2) THE CAPABILITY OF IMAGE SEGMENTATION
It refers to the ability to separate parts of the image that need to be identified, and these algorithms are aimed at the specific target to be identified. Therefore, the cloud platform is required to complete the segmentation operation by calling the corresponding algorithm, and calculate the corresponding segmentation accuracy to test the image processing effect.

3) ACCURACY OF IMAGE RECOGNITION
According to the image recognition rate, the recognition performance can be directly seen. Cloud platform will have completed the preprocessing and segmentation of the image with known image in the database, or read the text in the image for storage operation, the key to successful recognition is to grasp the degree of image processing.

4) RESPONSE TIME
It refers to the time to complete the whole operation of image recognition and time of specific steps such as low-level image processing, which can be used as the evaluation basis of the metrics of specific target recognition efficiency. The rest of the attributes have been discussed before and will not be elaborated on.

5) THROUGHPUT
It determines the maximum speed of image and data transmission between cloud platform and robot, and its size will affect
6) STABILITY
It is required that the cloud service should maintain a stable state for a long time when the service robot is engaged in the operation of license plate recognition, face recognition and other functions, otherwise it is easy to cause some things to be delayed. The expression forms of its metrics have been summarized before and will not be described here.

7) INTEROPERABILITY
It refers to the cloud platform through call interface to achieve image processing, model recognition and the ability to interact with the service robot, other aspects of the business have been explained before.

8) TESTABILITY
Algorithm of each image recognition step in the cloud platform is evaluated to ensure that the function is complete and the performance is reliable. Other functions and characteristics have been described in detail above.

9) FAULT TOLERANCE
In the process of specific target recognition on cloud platform, second confirmation is carried out, and the effective feedback mechanism is implemented for fuzzy or difficult to confirm face, license plate and other images. Other features are summarized in the front of the article and will not be explained here.

10) THE CAPABILITY OF NETWORK ATTACK PREVENTION
For example, in the process of face payment recognition, when data transmission between cloud platform and robot is carried out, it is easy to be intercepted by hackers. Hackers can modify or steal information, which will cause personal information leakage and even property loss of users. Therefore, cloud platform should ensure the security of data in the process of identification, and conduct security assessment regularly.

C. SPEECH RECOGNITION
Firstly, voice signal acquisition is completed through voice acquisition device equipped on the service robot or voice acquisition and analysis system in the robot computer terminal. Then the collected voice signal is checked to ensure that it has enough signal continuity to carry out the subsequent recognition operation. Before the speech recognition, first and last end of the silence should be cut off to reduce interference to the subsequent steps. After that, the voice should be analyzed, and moving window function is used to divide the voice into frames to refine the speech. At this time, the waveform almost does not exist in the time domain. It has the ability to describe, so it is necessary to transform in waveform, such as MFCC feature extraction, to transform each frame waveform into a multi-dimensional vector. After that, it is convenient to use the trained acoustic model to transform vector matrix into text or classify the results according to phoneme. In addition to the voice acquisition can only be completed by the service robot itself, other processing operations can be completed by the cloud platform or the service robot computer terminal. However, considering that the cloud platform is more convenient and fast for speech signal recognition processing, there is no need to equip each robot terminal with a system. Therefore, this paper considers the voice recognition into the QOS of metrics framework in cloud platform.
The business process of speech recognition can be summarized as signal acquisition, signal processing and recognition operation. Signal continuity detection, signal processing and speech recognition can be carried out by the cloud platform. If the voice signal transmitted by the service robot to the cloud platform has great discontinuity and is difficult to process and identify, it can be regarded as invalid signal and no longer be processed. Before processing, signal continuity detection is required and the metrics of signal continuity are introduced. The evaluation metrics of signal processing process in cloud platform is similar to that of image processing, so it is not analyzed here. The groups of metrics of response time, throughput, stability, interoperability, testability and network attack prevention capability are introduced. In this paper, considering the current recognition technology and actual demand, it is difficult to achieve one-to-one correspondence conversion between speech and text. Only by recognizing the specific meaning of the expression, the recognition is considered to be successful. In this paper, semantic recognition rate is introduced. The function of some service robots is to classify the attributes of musical instruments, such as gender, age, etc. The following describes the groups of metrics included in speech recognition:

1) **SIGNAL CONTINUITY**
   If signal is too long or the signal is intermittent in the transmission process, the cloud platform may misjudge broken sentence or terminate the speech recognition service in advance due to not receiving the subsequent signal in time, which may lead to recognition failure or deviation. Therefore, the cloud platform needs to evaluate continuity of the input signal.

2) **THE CAPABILITY OF SIGNAL PROCESSING**
   The ability to reduce excess content of a signal by converting the signal into a form that is easy to process, transmit, analyze, and recognize so that subsequent text conversion operations can be more accurate.

3) **SEMANTIC RECOGNITION RATE**
   Even if the service robot does not receive all the speech due to noise interference, if it can complete user’s requirements according to the keywords, the recognition is successful, and the groups of metrics is more suitable for actual needs.

4) **CLASSIFICATION ACCURACY**
   In order to analyze the voice data, the cloud platform should also classify the speech recognition, such as according to people’s age, gender, musical instruments, tones, etc., the cloud platform needs to call appropriate algorithm for classification operation.

5) **RESPONSE TIME**
   It refers to complete process of speech recognition and time spent in each stage of speech processing and analysis. It can be used to measure the performance of speech recognition. Other attributes have been described before.

6) **THROUGHPUT**
   If the transmission rate of voice signal and recognition result transmitted by cloud platform and service robot is too low, it could lead to serious problems such as slow transmission speed and signal loss, which will lead to incomplete analysis of voice signal. Other features have been discussed before.

7) **STABILITY**
   For example, some service robots with speech recognition performance are specially applied to people with physical defects. They mainly rely on voice to command the service robots to ensure stability of the cloud platform and keep robots in service for a long time. Other business aspects have been described before.

8) **INTEROPERABILITY**
   The cloud platform successfully calls the ability of speech analysis, processing algorithm and recognition model. The rest content is similar to specific target recognition and will not be described here.

9) **TESTABILITY**
   The process and method of evaluating the performance of speech signal analysis, processing, translation and other algorithms as well as the implementation of each function are described in the previous paper.

10) **THE CAPABILITY OF NETWORK ATTACK PREVENTION**
    Some voice signals are related to privacy of users. In order to avoid leakage, the security evaluation should be strengthened, and the key point is to protect the data information in the process of network transmission.

**VI. CONCLUSION AND FUTURE DIRECTION**

With the market development and application integration of public cloud and private cloud, as well as a series of policies on cloud computing industry issued by many governments, more and more intelligent services are linked with cloud services. Some well-known enterprises such as Alibaba, Huawei and Inspur have launched their own cloud platforms, and the data of many enterprises have also been transferred to cloud servers not only to save hardware costs, but also to improve efficiency, cloud services have become an inevitable trend of future development. The cloud robotic platform, as a product of development of the times, can not only provide corresponding function services for the service robot, but also save the equipment and built-in cost of the service robot, improve the QOS, and has strong expansibility and extensibility. The QOS metrics framework of cloud robotic platform is a metrics framework which comprehensively considers the software QoS, network QoS and service robot which are suitable for the cloud robotic platform. According to the metrics framework, we can comprehensively evaluate the cloud robotic platform, find out deficiencies of the cloud platform function and performance, so as to improve the QOS of cloud platform and make corresponding planning suitable for the future development of cloud platform.
The original cloud platform is to provide a more economical and convenient way for centralized storage. At present, it has been developed into a computing cloud platform based on data storage and data processing, and the technology is becoming more and more mature, and the process of providing services has become gradually simplified. As far as the cloud robotic platform is concerned, its main function is to call the corresponding algorithm and store and process a large number of data in the cloud platform as the service robot. The maturity of the platform technology has a great impact on the development of intelligent service robot and modernization of service industry in future, and has broad development prospects. But at present, there are still many limitations in the scope of services that cloud platform can provide for service robots. The monitoring and evaluation capability and scope of cloud platform still need to be improved. In face of network attacks, how to do a better security defense and other issues need to be solved. And with the rapid development of science and technology, service robots have been gradually applied in various fields, such as medical treatment, education and entertainment, military, rescue, scientific research and other fields, and their functions will become more and more complex. These service robots will also rely on cloud services to realize their functions as the development trend in future. Then how to better integrate the cloud platform with the service robot, and how to further strengthen the performance of the cloud platform and make the cloud service more intelligent. Based on the above problems and challenges, the following six development directions are proposed.

A. IMPROVE THE UNIVERSALITY OF CLOUD SERVICES
At present, proportion of robots that can complete services through cloud platform is not very high. Due to limitations of transmission rate, delay, power consumption, system capacity and large-scale equipment connection, some service robots are still difficult to rely on the existing technology and algorithm of cloud platform to complete their functions, such as “zero” required by mobile robots for obstacle detection “Delay” and real-time control of the force and angle of grasping robot when grasping the object through arm are the services that are difficult to realize in the cloud platform at present. It can be seen that in the final analysis, it is still lack of processing and communication capabilities of cloud platform. With the advent of 5G era, commercialization and popularization of 5G is expected to solve this problem, so that more service robots can complete their functions by calling cloud services. The evaluation of cloud service popularity can be studied from the call of algorithm on cloud platform.

B. ACCURATE AND DETAILED MONITORING
At present, the evaluation of cloud platform is limited. In order to improve self-evaluation ability of cloud platform, it is necessary to make the cloud platform analyze information more deeply and dig out more valuable information. meticulous monitoring will make the system detect abnormal time ahead of time, avoid occurrence of major accidents, and also make the evaluation results more accurate. How to further ensure that users, robot manufacturers, algorithm providers and service robots can clearly understand the service usage of the cloud platform at any time and anywhere, so that the cloud platform can timely understand various changes, such as virtual machine state of service robot connection, increase of various types of requirements, online and offline service, etc., is a problem that needs to be studied in depth. And to test and compare the more perfect monitoring functions, we can start with the operation tracking of cloud platform to users.

C. PERSONALIZED SERVICE
At present, the application of service robots in different scenarios is very simple. For example, robots used for medical treatment are only used in the medical field, while robots for delivering meals can only provide services in limited areas such as hotels. In future, service robots must be able to perform multiple functions like ordinary people, and require cloud platforms to carry out “private customization” according to different needs. Therefore, the realization of service personalization and privatization is also a development direction of cloud platform in future, which makes the service of cloud platform more rigorous, targeted and purposeful. Investigation of personalized service can be carried out from logic of algorithm combination, rigor and specific service effect.

D. ENHANCE SECURITY
As far as the current encryption and cracking technology is concerned, it may take tens of thousands of years for computer to crack some passwords. However, due to development and breakthrough of quantum computing, any algorithm encryption based on network and other technical defense means will not be able to pass test of quantum computing. At present, it seems that the powerful encryption technology is likely to be broken within seconds. As a new application mode, cloud service, compared with traditional Internet, is bound to cause new security risks due to high concentration of data and multi-user access. Once the security system of cloud platform is broken, the loss is immeasurable. How to solve the security problems including cloud infrastructure security, data, authentication and access management security and compliance audit is still a technical problem. With development of science and technology, a more perfect security system may appear in near future. At that time, simulation attack can be further studied and evaluated according to the more advanced network attack technology.

E. PAY ATTENTION TO EDGE COMPUTING
When service robot realizes voice recognition and other functions, it needs to transfer data to the cloud platform and make decisions based on the cloud platform for calculation and analysis. When amount of data is small, the cloud platform can accurately and efficiently feed-back results. However, if the service robot directly transfers a large amount of collected data to the cloud platform for processing, it will not
only increase amount of computing on the cloud platform, resulting in reduced efficiency, but also the more data transferred, the more likely it is to lose packets, and the security and privacy issues are difficult to be solved. So how to solve this problem, one idea is to make a lot of data simple processing or important information extraction by edge computing, and then send it to the cloud platform for decision-making, so as to avoid a large amount of data exchange with cloud computing data center. This mode of cloud computing + edge computing is a development direction in future. Cloud platform can evaluate enhancement effect of the number of nodes in edge computing on computing real-time and the adaptability of data sets.

F. GROUP INTELLIGENCE CONSTRUCTION

At present, algorithm and other functions called by the cloud platform are provided by a single group such as algorithm providers. If only relying on it to develop and build a cloud platform is not conducive to construction and further improvement of cloud platform, how to realize the efficient construction of cloud platform. We can learn from the idea of open source, gather through Internet and use the power of large-scale group wisdom to help complete the construction of cloud platform, accelerate the improvement progress of cloud platform, and improve the QoS of cloud platform. We can carry out research according to the scale of cloud platform group intelligence construction and the change trend of service performance.

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