The Teleoperation System of Service Robot Based on Cloud Services

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Abstract. At present, China has become the world's manufacturing powerhouse, but not a manufacturing power. The rapidly aging population, labor costs increasing year by year and economic restructuring and adjustment of advances in technology provided a wide range of power for the development of robot technology. China has become the world's largest market for industrial robots for two consecutive years and will become the world's largest robot market. Meanwhile, China introduced a number of policies to support the development of robot technology. "Internet +" provided a new model of development for the robot intelligence, integration and service-oriented. In this paper, we study on teleoperation control system of service robot whose aim is to develop "operator-mobile Internet-robots–environment" cloud robotics systems. The system uses a master-slave teleoperation mode, so that the robot is under the distal end of network operator real-time control. Divided into three parts: Main operator terminal is the multi-mode control terminal; Stereoscopic capture system use Microsoft Kinect equipment for the body to complete the data collection, analysis, and sends each joint angle of the robot end, driving the robot to move jobs; Computer-based software client control system has achieved control of the mobile platform. Use a network server deployed in the cloud to complete the multi-transmission system tasks and decision-making data and it has now achieved data transmission. The end of the multi-terminal configuration to perform the robot includes the independent design and processing inspection robots, integrated mechanical properties Mecanum wheel full mobility; In the autonomous navigation operations to improve service, we build a versatile and full range of cloud services teleoperation control system.

Keywords: cloud services, control system, Internet, robot, teleoperation

1 Introduction

Robot teleoperation means that humans can control the robots in a dangerous or long-range environmental remote operation system. Robot remote control system generally has four parts: on-site operations, sensing systems, communication systems and feedback systems. Due to various reasons, humans often need to work under high temperature, high pressure, high radiation, hypoxia and other hazardous environments. The study and implementation of remote operation of the robot is hot research field [1].

Fig. 1 shows that the telepresence of teleoperation system includes visual feedback and force feedback. The operator is in the remote away from dangerous work environments [2]. Arranged with cameras and a force sensor, the operator can be fed through the front camera, video and audio information on a remote robot to determine the job situation at the scene. The same time, the operator can be combined with video feedback according to the size of force feedback remote manipulation of the handle for precise operation.

With the rapid development of Internet technology and mobile Internet, network-based robot teleoperation research developed [3]. Internet plays as a medium of information transmission. The network operator becomes a carrier of an action to extend the range of human work, achieving human remote operation of the robot. The robot becomes agents.
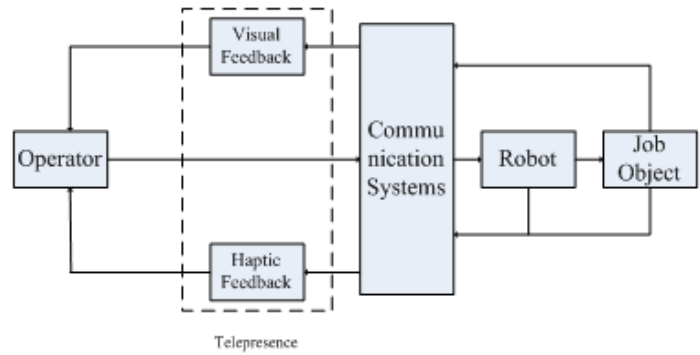
Fig. 1. Teleoperation system of robot

Ken Goldberg created the first robot remote control system based on the network [4]. Operator gets access to robot through the Internet. They send control commands for remote operation. Then they devise a multi-operator simultaneous control of the distal end of the robot teleoperation system. When multiple commands simultaneously issued, the algorithm is utilized planning and coordinating of multiple commands [5]. Then make execution. K. Taylor used the position control method. The robot achieves job tasks by sending the robot joint position [6]. The system also has real-time feedback to enable operators to keep abreast of the dynamic front-end.

Due to limited robot body mechanism, controllers, sensors and other technology, autonomous mobile robot operation is difficult to achieve in complex or unknown environment. Therefore, many experts believe that more realistic from Teleoperation model is based on primary human-computer interaction techniques. This acquired based telepresence teleoperation mode can greatly increase the ability of humans to remotely control the robot operation at the current stage. United States, Germany, Japan, Britain, France and other countries have invested a lot of human and financial resources to study robotics and telepresence technology. Construction, design and tremendous of robotics telepresence teleoperation system made great progress after years of research [7].

In this paper, we study on teleoperation system of services robots. Man-machine collaborative approach is used to solve the key technical obstacles of addressing service robots to life. The aim is developing "operator - Internet - Robots – environment" cloud robotics systems. Establishing two-way messaging platform based on the mobile Internet makes the robot operator at both ends of its network. The operator can use many types of operation device to send control commands to the robot. The robot receives a command, execution of the job, so that the distal end of the robot becomes the operator of the "agent" to complete the task of moving jobs. At the same time we are looking forward to achieving autonomous robot operation [8].

2 The Teleoperation System of Service Robot

This article aims to develop "operator-Internet-robots-environment" remote manipulator system [9]. Establishing two-way messaging platform based on the mobile Internet makes the robot operator at both ends of its network. The robot receives a command, execution of the job, so that the distal end of the robot becomes the operator of the "agent" to complete the task of moving jobs. We designed a robotic inspection system for the job tasks [10].

2.1 The Design of Teleoperation System

Teleoperation system topologies constructs are shown in Fig. 2.

Primary-side deployment site operator consists of human motion capture and multi-mode surveillance system [11]. It completes generated work of the robot motion control commands. Stereoscopic capture system uses Microsoft Kinect equipment to complete the data collection, analysis for the body. It sends each joint angle robot end and drives the robot to move the job.
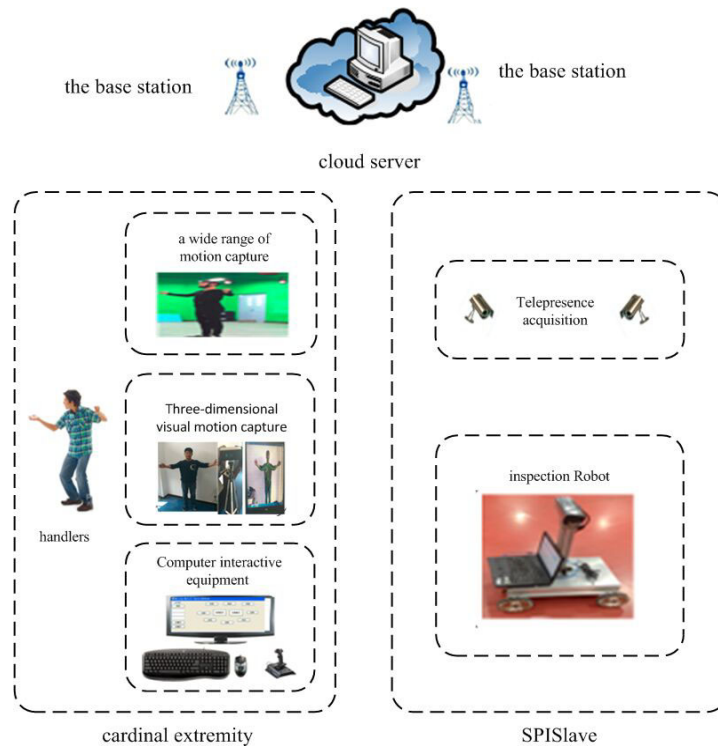
Fig. 2. Teleoperation system topology

Cloud data transmission and storage platform consists of the Internet and robots dedicated servers. It completes the multi-point data transfer between the robot motion pattern storage and retrieval system operation safety decision-making work. Currently, the use of the transmission control command has been deployed in the cloud network server, implemented in a network environment have inspection robot teleoperation control.

The end of the interactive objects are located in the operator situational awareness and robot motion platform. It used to complete the interactive object, real-time motion control robot work. The end is the performance of the robot, including the independent design and processing inspection robots [12].

2.2 Multi-mode Control System

A wide range of motion capture. System introduction: Large-scale motion capture system will be the trajectory of the detected object tracking within the specified range. It captures the spot on the object to complete the gesture capture purposes [13]. For a captured object, the arbitrary point when the system on which to quickly capture a point at the same time, over a continuous period of time. We can calculate its trajectory through the analysis of consolidation [14]. Two loom can be captured. The system can determine this based on the location of the information obtained. Analysis system we used in the experiments in various fields includes film special effects, animation, and control engineering. The system can be carried out indoors, in the case of direct exposure to the sun's rays the situation most accurate optical motion capture and motion analysis and even outdoor day [15]. The system can measure the micro three-dimensional platform motion measurement and up to six degrees of freedom. This allows us to capture a stereoscopic robot's eyes when having a small environmental restrictions, and digital motion so many landmarks such precision capture captured have great assurance [16].

System components: The system is based on infrared motion capture. It has a total of sixteen shots, twelve of which are distributed around the room. The arrangement for the purpose of multi-angle no blind spots to capture the body's movement are shown in Fig. 3. Raptor-4 (see Fig. 4) uses advanced technology to ensure true effectiveness of the experiment. With the improvement of people's requirements and the accuracy of the experimental data acquisition needs become more and more. The request signal stability of the system is also increasingly high. Raptor-4 are connected by Internet hosts.
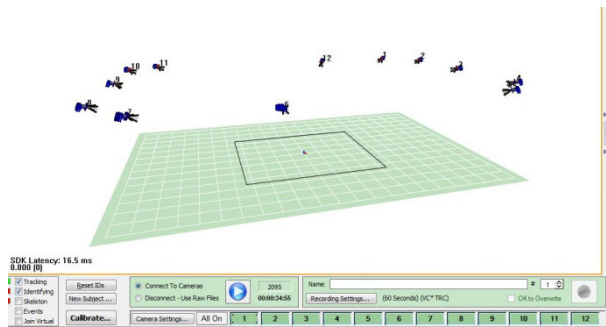
Fig. 3. Large range of motion capture system configuration

Fig. 4. Raptor-4 used in the experiments

System Experiment: Start-up: Fig. 5 shows the total number of motion capture cameras in working condition in the software interface.

Fig. 5. Motion capture the spatial position of the camera and capture areas

Demarcate: When the system and the camera has been successfully connected, we need to calibrate the motion capture space [17]. First, calibration L type long axis act as the Z axis. The major axis direction are toward the bench. Start the calibration process when selected calibration button. After we selected the camera used to change the color, it represents our calibration successful. The entire calibration process is not complicated. Calibration principle is equivalent to the establishment of the axes in the areas of our motion capture. Twelve motion capture cameras that we have selected will be on the detected calibration data for analysis in the process of establishing the coordinate axes [18]. Thus each motion capture cameras determines the position of the space axis. In order to improve the accuracy of motion capture cameras, we also need dynamic calibration of the entire system after conducting static calibration. It is what we call the T-shaped calibration. Operator hold a T-shaped rod motion capture calibration regions waving. Cover the entire space as much as possible and strive to full coverage, so motion capture camera trajectory will point real-time recorded by the camera [19]. It is possible to accurately determine the relative position between the camera and is capable of such a dynamic situation on the position of the entire space a more accurate calibration, so that the spatial position of complete motion capture system error after a two calibrated, accurate spatial location to reach a more precise degree that motion after the sys-

tem capture process can be accurate, fast, efficient operation. Fig. 6 and Fig. 7 show a result of our soil spatial calibration. It needed to reach the standard U-Res and V-Res less than 0.2. It is clear that all the data up to the standard which means that we have this calibration times is successful [20]. Then save the calibration results and use the calibration results in the motion capture process.
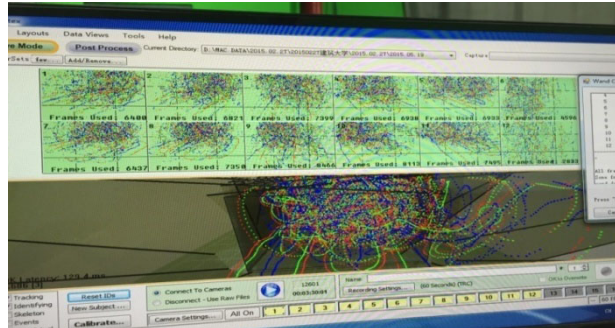

Fig. 6. Dynamic calibration process

Fig. 7. Dynamic calibration results

Modeling: Firstly, we performed in accordance with the set point paste. Paste luminous points on the human body. These points are captured by the camera motion capture points [21]. Fig. 8 shows that the experimenter in left figure is wearing a particular dress and glue light emitting point of the picture. The image on the right is the camera motion capture system in the captured image [22]. Fig. 9 shows how to create a virtual robot. Modeling process of virtual robot needs to be adjusted proportion actor. Each point in the actor's call Talon. It real-time drives. In order to achieve the modeling process, put the captured dots model and human model we want to create correspondence ultimately through these processes. Fig. 10 shows a mannequin image that we build.
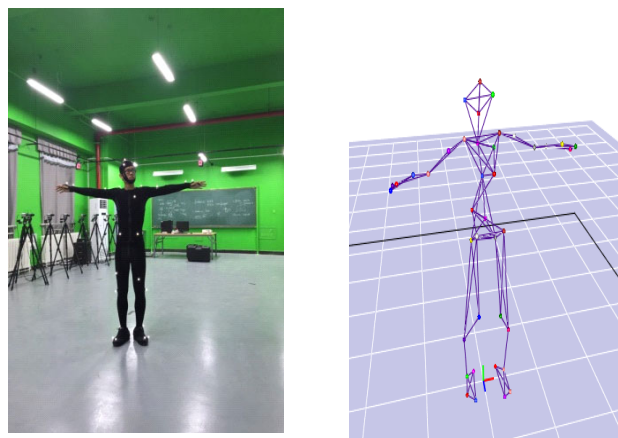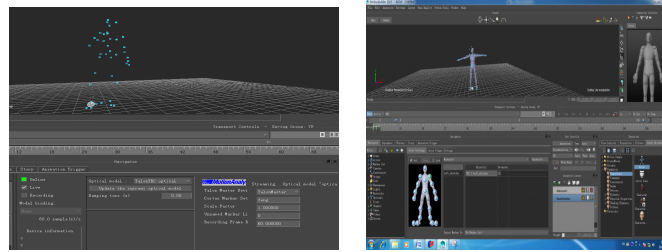

Fig. 8. The experimenter and captured images

Fig. 9. Human body modeling

Fig. 10. Effect picture

A wide range of motion capture. Stereoscopic motion capture：Kinect identifies the key point lying in the depth of the image processing on the human body. Kinect will scan the overall outline of the acquired image, followed by carrying out the details of the analysis. Kinect in the scanned area, the overall outline presented "big" shaped thing. Kinect will be considered a human target. Firstly, it will locate the presence of the target [23]. Then, we analyze image and video stream input further based on the basic features of the human body, including the location of people, information and other characteristics of the target. Thus extract identify the body in the complex environment. Kinect gathers depth image information [24]. We can obtain human skeleton model contains twenty human skeletal point of 3D information using Kinect for Windows SDK toolkit package function. Its two-dimensional projection is shown in Fig. 11. According to the human skeleton model Kinect for Windows SDK provided in real time, you can obtain the location of bone node at a time. Then we get the angle and the relative position between the bone node through the SDK functions. Clarify the three-dimensional coordinates of the body. Fig. 12 shows the system of a human skeleton.
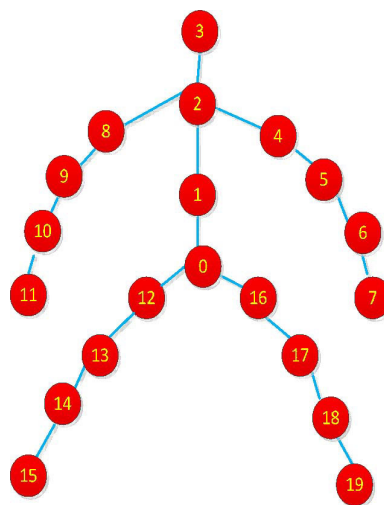
**Fig. 11.** Twenty skeletal point of human

Fig. 12. Tracking human skeleton

3 The Design of Inspection Robot

This paper is an Internet-based service teleoperation system. We construct teleoperation platform of robot based on cloud platform. We will introduce the structure and composition of the inspection robot and related properties detailly.

3.1 The Design of Inspection Robot

We have designed a robot patrol for certain architectural indoor and outdoor complex environment. The biggest advantage is the integration of this paragraph robot mechanical properties Mecanum round, comprehensive, zero turning radius of the mobile robot can be achieved, especially for the mobile space-constrained environment [25]. Fig. 13 shows inspection robot system. The robot uses a PC. Based on the foregoing analysis, CAN bus communication method of the present robot is used.
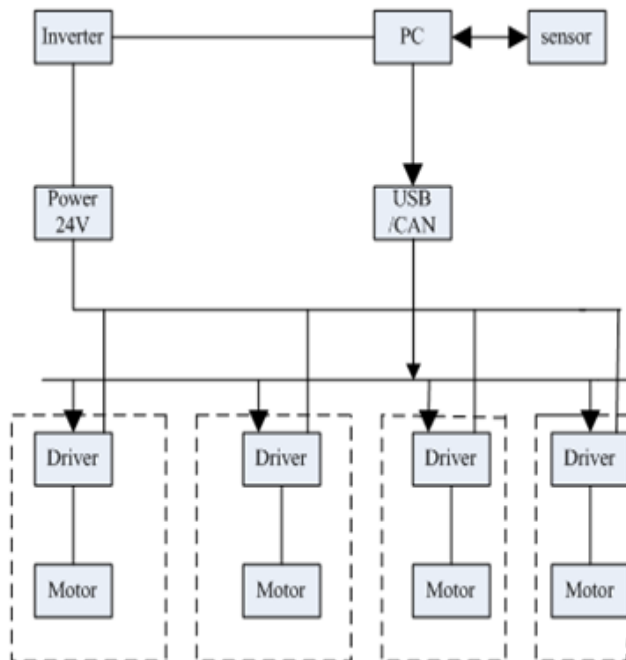

Fig. 13. Inspection robot control chart

Since this paragraph robot can achieve forward, backward, lateral, comprehensive mobile features turning on the spot and other major asset is Mecanum round of the mechanical properties, as will be described and analyzed.

3.2 Motion Characteristics

Mecanum wheel axis consists of an outer ring of metal wheels and metal connected to the hub without power roller can roll on the outer edge of the composition [26]. Each roller and the wheel hub was a certain angle. Roller in addition to as a hub around the axle revolution, can also rely on the robot travels surface frictional force around the roller coupling shaft rotation [27]. Velocity of the revolution and the autobiography of the combination plus the rollers and wheels are angled [28]. This is the basic principle Mecanum wheel that can be a full range of motion.

3.2.1 Layout Mecanum Wheel

Fig. 14 shows a few typical four wheel layout structure, icons 1, 2, 3, 4 represents a block diagram showing the four wheels, each wheel bias in the roller frame slash azimuth direction of the contact surface (contact surface from the roller surface of the roller in the opposite direction) to watch [29]. But its ability to achieve full range of motion not only depends on whether the inverse matrix of full rank, must consider the performance of the drive system. Figure a, b structure meets two full rank, but for a diagram of the structure [30]. If the layout of the structure is a perfect square, four wheel offset angle equal to the time. Its velocity is zero, you can not achieve around fixed axis. The system can only achieve the two degrees of freedom. It can not achieve full range of motion. Therefore, only panel b kinds of layout structure achieve full range of motion.
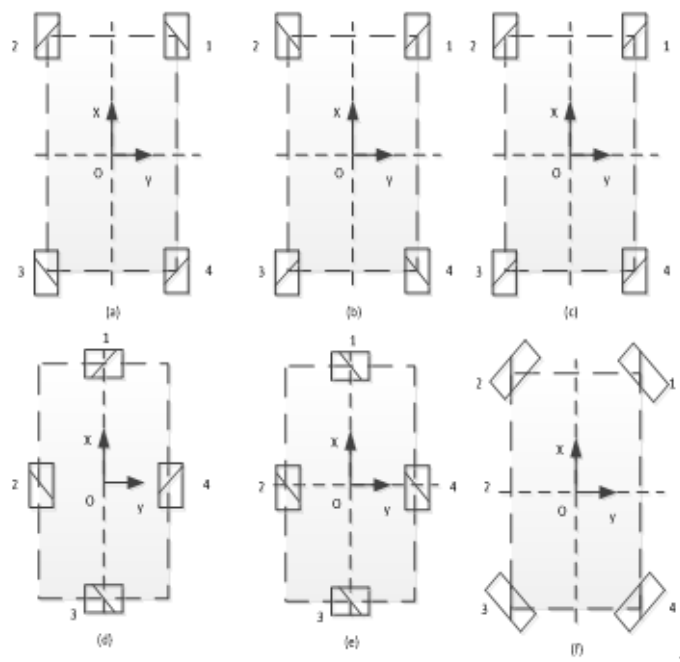
Fig. 14. A typical four layout structure

#### 3.2.2 Movement Pattern analysis of Mecanum Wheel

For the robot has Mecanum round, when the motor drive hub rotates on Mecanum wheel small wheel under the action of friction while rotating around each small wheel also own axis, changing four wheels the steering wheel can be small by changing the direction of rotation, thus changing the state of the mobile robot [31]. TABLE1. lists the movement patterns of each wheel forward and reverse when robots. W1, W2, W3, W4 respectively represent four wheels, 1 turn, -1 for reversed. Table 1. shows the relationship between the speed of robot movement pattern and direction of each wheel. By analyzing the force of each wheel is obtained reasonable overall robot, but also can determine the movement of each wheel in a different state of motion of the robot. When Mecanum wheel driven by a motor to rotate the wheel in the normal manner along the vertical direction of the drive shaft, Mike Dunham wheel around the small wheels about their respective axis of rotation independent [32]. These roller periphery into a certain angle, the surround is formed in a cylindrical surface, a portion of the wheel axle through a certain angle of the

steering wheel force into a normal force. With the speed and direction of each wheel in any direction desired final overlapped to form a resultant vector of these forces, resulting in the ultimate direction of the resultant force vector so that the robot can move freely without affecting the inherent direction wheels [33]. Fig. 15 shows the direction of movement of the wheel assembly platform Mecanum schematic diagram of rollers hatched touchdown when roller axis direction promoter in a different state of motion.

Table 1. Ationship of each wheel

W_1	1	-1	-1	1	-1	1	0	1
W_2	1	-1	1	-1	1	-1	1	0
W_3	1	-1	-1	1	1	-1	0	1
W_4	1	-1	1	-1	-1	1	1	0
mode	go-ahead	retreat	right	left	clockwise rotation	anticlockwise rotation	upper right	upper left
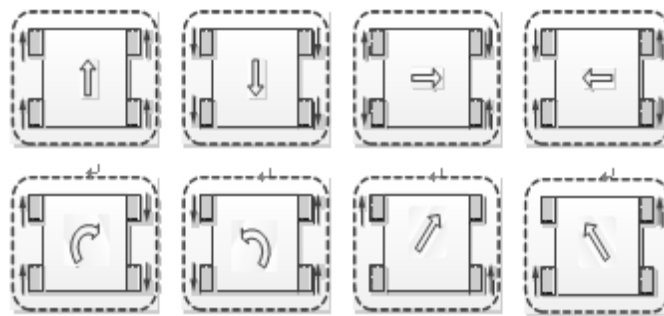
Fig. 15. Mecanum wheel omni-directional mobile schematic

4 Experiment and Results

We do a comprehensive inspection robot motion experimental research and inspection robot teleoperation control using the robot teleoperation system that we design and build.

4.1 Full Range of Motion Experiment of Inspection Robot

Mobility characteristics during the experiment over a wireless mouse to operate, control robot to achieve forward, backward, lateral, in situ rotation, etc. Below is a video shot during the experiment.

4.1.1 Forward

Fig. 16 shows respectively at time T, T + 1, T + 2, T + 3 video shots of the robot at the top of the stereo camera and a red cushion on the floor as a reference. Implement accelerated motion of the robot is through a continuous click forward button in the process of moving forward [34].
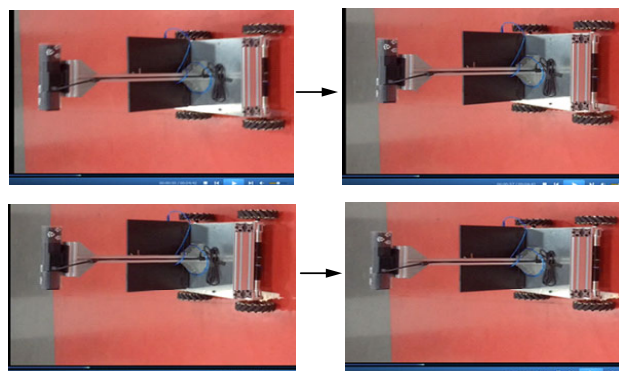
Fig. 16. Forward

4.1.2 Retreat

Fig. 17 shows respectively at time T, T + 1s, T + 3s, T + 4s video shots, the same robot to the top of the stereo camera and a red cushion on the floor as a reference. Implement accelerated motion of the robot by a continuous process click the Back button in the back.
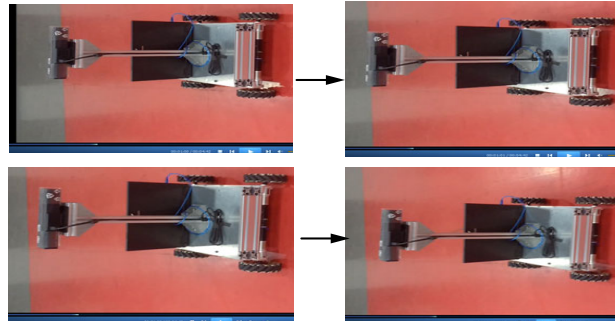

Fig. 17. Retreat

4.1.3 Side Row

Fig. 18 shows respectively at time T, T + 3s, T + 6s, T + 10s video shots, to the floor of the red pads as a reference. The robot can be seen in a certain speed to the left pan.
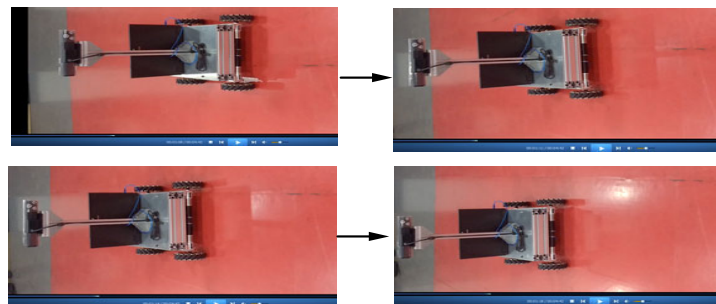

Fig. 18. Side row

4.1.4 In Situ Rotation

Fig. 19 shows for the robot in place of zero radius of rotation to the left.
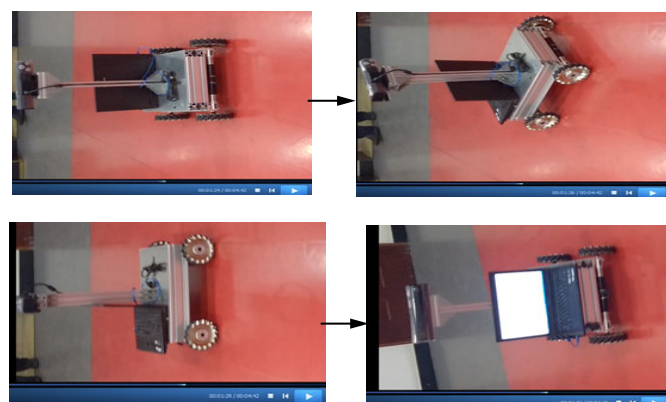

Fig. 19. In situ rotation

During the experiment, the robot can achieve multi-directional movement of free to switch [35]. You can instantly switch from forward to backward state, lateral, in situ rotation. The experiment in the indoor venues, as floor coverings have pads, rock is relatively small in the process of moving, run more smoothly.

4.2 Teleoperation Control Experiment of Inspection Robot

Since this project is to study the operation of an Internet-based remote control robot, experimental procedure teleoperation. This experiment operator located in building 3 experiments. The server runs in building 5. Ip is 10.12.32.140. Firstly, turn on the server. The operator can get live video information by installing a few people at the top of the camera, according to the scene to control the robot to move [36]. In this study, by implementing the robot about the activities of the centre badminton bypass week at the operator's remote control, and passed the site entrance as shown in Fig. 20.
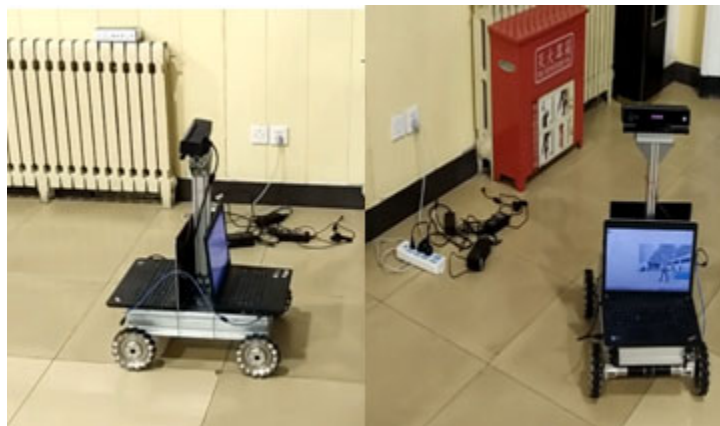

Fig. 20. Preparation stage

Fig. 21 shows for the robot to move the process along the right side of the site. Due to the more open forward visibility, operator video information obtained through the camera more comprehensive [37]. So in this stage with operator himself can be remotely by using video surveillance operating with the robot. The process can always change the movement pattern of the robot [38].
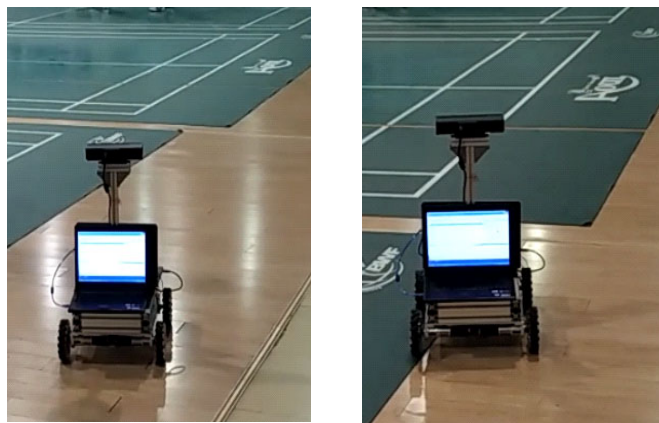
Fig. 21. Phase forward

Fig. 22 shows for the robot along the rear side of the process of moving the site. Since the front portion of the process there is an obstacle, so the procedure for remote operation requires the location and size of the obstacle. The robot moves ahead adjust posture in order to smooth the passage.
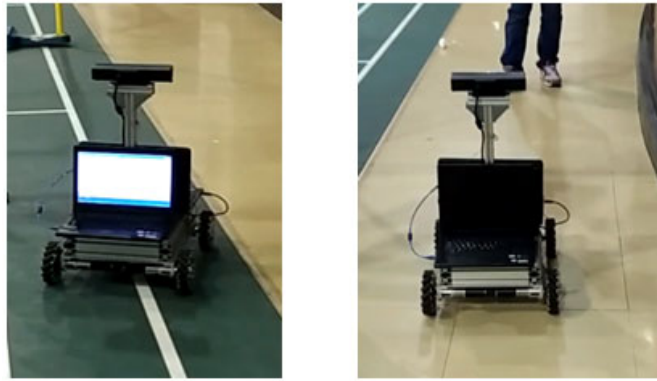
Fig. 22. Turn forward

Fig. 23 shows for the robot and back along the left front side of the mobile site process.

Fig. 23. Regression process

Fig. 24 shows the robot through the site entrance process. In this process by the operator alone video surveillance to observe the location of entrances and exits, and then continue to adjust the movement of the robot posture. It passed the entrance finally. But in the process of back and forth through the entrances to adjust the posture of the robot several times to advance through the attitude. Not the other side of the line, such as the way through. The robot can not be switched because of the attitude transformation network transmission delay.
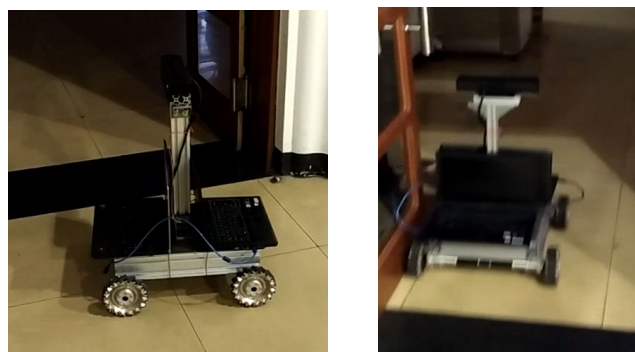
Fig. 24. Through the entrance

5 Conclusions

With the increased demand for social, service robots especially will become future research. The man-machine collaboration or teleoperation robot system will be a trend. The current robot teleoperation system user experience is poor, but the current system does not teleoperation good scalability. The robot can not be added anytime, anywhere to the system. With the development of computer networks, especially

the big data, cloud computing progress, so have a higher cloud services platform resource sharing capabilities, scalable, on demand, virtualization and other features, will have broad application in the field of robotics prospect. This research to build a robot cloud platform, provides a configuration diverse users huge, full range of robot control platform. The user view system connections through the robot platform. Select the desired robot types and control mode, perform robot operation. The robot feedback sensor information and audio and video information the operator can see more clearly uncertain robot execution status and related properties of the cloud operating system platform cloud-based system has good scalability.

Acknowledgment

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