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# Research on Simulation Robots Based on the Needs of Peaceful Community Construction

***Abstract: -*** The visual simulation level of the simulation robot is not high, and its sense of social presence is also insufficient at present. It is difficult to meet the social needs of closed community management, safe community construction and other aspects in public health events such as the COVID-19 epidemic. For this purpose, this project adopts research methods such as literature, simulation, and empirical research to develop a simulation robot, which is responsible for community security, publicity, consultation, communication, receiving and receiving, and charging. Empirical research has shown that the size of the robot is consistent with that of a real person, with a highly humanoid appearance. The movements of its upper limbs and head basically conform to human behavioral norms, and it can undertake security and other tasks in community services, providing people with a better immersive experience and social presence.

***Keywords:*** Peaceful Community (PC), Simulation Robot (SR), System Composition (SC), Motion Mechanism (MM), Distributed Structure (DS), Action (A).

## I. INTRODUCTION

Simulation robots, also known as humanoid robots, are a type of service robot and a type of advanced robot. They have a very human-like appearance, with skin, hair, and height that appear similar to humans, and even have facial expressions, speech, movements, tone, and other characteristics similar to humans. They are able to complete basic communication, so simulation robots have a good "sense of social presence"[1] and can provide an "immersive experience"[2] for people.

The Kengoro robot [3] developed by the University of Tokyo in Japan is one of the robots that closely resembles a human. It is 1.7m tall and weighs about 56kg, similar in height and weight to an average person. It is equipped with 108 motors and 114 degrees of freedom. The Atlas humanoid robot [4], developed under the leadership of Boston Dynamics in the United States, is 180cm tall and weighs 150kg. It has 28 degrees of freedom in all four limbs and is composed of hydraulic actuators designed specifically for various search and rescue missions. Talos robot independently developed by Shenzhen Leju Robot Technology Co., Ltd. has 22 joints that can rotate at a high speed. It has high-precision digital servo steering gear, advanced gait algorithm and humanoid technology. When walking, its body shape is almost identical to that of a human. But the difference in appearance between the aforementioned robots and real humans is still significant.

This project was approved at the beginning of the outbreak of the COVID-19, aiming to develop a simulation security robot to solve the problems of insufficient manpower and infection of management personnel in the closed management of communities during the epidemic. Although the COVID-19 pandemic has ended, in the context of an aging population and fewer children, the scarcity of human resources and the increase of human costs will be important factors affecting community governance that cannot be ignored [5]. Fortunately, as China enters the aging population, it will also enter the era of AI and metaverse [6]; Traditional communities will transform into smart communities, which can strengthen community governance and save valuable human resources. Therefore, the research and application of simulation robots is an inevitable requirement for software hardware collaboration and technological empowerment in the construction of safe communities.

Both safe communities and smart communities currently lack international or national standardized frameworks. In the case of "Hefei's Smart and Safe Community initiative, the primary focus is on four major areas: community security, public safety management, community services, and comprehensive governance. The content includes the construction of a standard system, two city-level platforms, and a multi-technology integrated multi-

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dimensional perception system"[7]. Within this context, the perception system can be likened to the sensory organs of a human, collecting and transmitting information through various recognition methods such as facial recognition, vehicle recognition, voice recognition, OCR, as well as technologies like various sensors and the Internet of Things. This system forms the foundational material and technological infrastructure at the lowest level of a smart community, taking the form of various end devices, including facial recognition cameras, voice recognition modules, automated temperature measurement devices, and intelligent gates, among others. However, these devices lack social situational awareness, which limits their functionality because "the higher the level of social situational awareness, the shorter the social distance, resulting in closer social relationships, more genuine emotions, and a stronger sense of trust"[8].

Based on the above, in order to meet the needs of safe community construction and people's sense of security and immersive experience, the research team has developed a community service oriented simulation robot through methods such as literature review, investigation, simulation, and empirical research. Empirical evidence shows that simulation robots serve the construction of safe communities with good economy, safety, practicality, and necessity. The significance of this article is to comprehensively introduce the system functions, composition, control, manufacturing, and existing problems of simulation robots, in order to facilitate the promotion of project achievements and the development of simulation robots.

## II. FUNDAMENTAL RESEARCH

### A. Basic Functions of the Simulation Robot

The community simulation robot falls under the category of service robots. It closely resembles a human in appearance, with human-like skin, hair, height, and even the ability to mimic human facial expressions, language, movements, and tone [9]. It is capable of basic communication and can perform certain community service tasks as a human substitute.

Community tasks are diverse, but due to the current limitations in the mobility, perception, and analytical abilities of robots, community simulation robots primarily undertake certain security, promotion, consultation, communication, reception, and fee collection tasks. Taking security as an example, this role is currently mainly handled by security personnel from property management companies and police stations, as well as various surveillance systems. It requires a significant number of personnel, resulting in high costs and relatively low efficiency. This is because security personnel need to work in shifts, leading to a high demand for human resources and high labor costs.

In the backdrop of a labor shortage, security personnel tend to be older individuals with limited education and potentially less capability in handling various situations. Robots, on the other hand, do not require rest or shift changes, and they do not face issues like infection risks related to viruses such as COVID-19. They can work around the clock, performing security, duty, reception, communication, and other tasks. This not only provides economic efficiency but also reduces the risk of infection for security and property management personnel during times of epidemic-related lockdowns.

In the current tasks related to security, promotion, consultation, and fee collection, devices such as surveillance cameras, automated temperature measurement systems, public address systems, and QR code payment terminals have significantly reduced the workload for humans. On one hand, these devices are, after all, machines and lack the "social situational awareness" and interactive affinity that simulation robots possess. They also lack the deterrence factor that is important when dealing with rule violators. On the other hand, these devices currently have single functions, limited interactive capabilities with humans, and inadequate self-protection abilities.

### B. System Components of the Simulation Robot

To achieve the aforementioned functions, the simulation robot studied in this project consists of three major systems: control, body, and peripherals. The body system serves as the robot's supporting framework, its execution unit, and its external appearance, encompassing three main parts: mechanics, physique, and attire. The mechanical part comprises the main structure, motion mechanisms, and auxiliary mechanisms, forming the robot's action system and key structure. The physique part includes the simulated body shell, highly realistic skin, lifelike eyes, and realistic hair, providing the robot with human-like appearance and features. The attire part refers to the clothing, footwear, headwear, and accessories worn by the robot. Research has shown that "users exhibit typical face-first recognition effects and first impression effects in their visual perception of humanoid robots. The head design of humanoid robots influences users' emotional and functional perception of the robot, with emotional perception taking precedence in determining user likability" [10]. Therefore, the body is one of the critical systems in the simulation robot.

The function of the control system encompasses input, computation, and output, involving information acquisition, computational analysis, and command output. In this project, the control section of the simulation robot includes the acquisition platform, safety platform, imaging platform, voice platform, motion platform, mobile platform, and system host:

(1) The acquisition platform utilizes various sensors to autonomously gather information about the environment and targets. It processes this information preliminarily and uploads it to the system host.

(2) The safety platform provides functions related to power management, voltage regulation, current limiting, energy conservation, and early warning, ensuring a stable power supply and basic safety.

(3) The imaging platform consists of software and hardware for vehicle recognition, facial recognition, human body temperature measurement, surveillance cameras, and more.

(4) The voice platform includes modules for voice recognition and intelligent responses.

(5) The motion platform controls the robot's motion mechanisms.

(6) The system host performs advanced processing of various types of information. It handles tasks such as learning, computation, storage, communication, navigation, and provides commands based on the processing results.

(7) The mobile platform leverages the advantages of reliable mobile communication, convenient interaction, rich apps, and powerful functionality through its interconnection with the system host, allowing it to replace the host in performing certain functions.

The peripheral system consists of facilities and devices external to the robot, which are set up to protect the robot and its data, as well as to assist the robot in accomplishing specific functions. This includes external monitoring cameras, external backup hard drives, guard booths, barriers, gates, parcel lockers, and more. The peripheral system serves as optional hardware for the simulation robot, and the most notable feature of a simulation robot is its highly human-like emulation. Humans have evolved over a long period, resulting in specific static images and behavioral norms. The former is achieved through a highly realistic physique, while the latter is achieved through motion mechanisms.

In the software aspect, the project team has outsourced the development of the main program for the system host's operation to a third party. They have independently developed the programs required for the acquisition platform, safety platform, motion platform, and other subsystems.

### *C. Motion Mechanism of the Simulation Robot*

Behavioral norms are habits and action standards gradually formed by humans during their evolutionary and socialization processes. To conform to human behavioral norms and aesthetic requirements, the motion of a simulation robot needs to imitate human actions and behaviors. The human body's motion system consists of three types of organs: bones, bone connections, and skeletal muscles. The human body has a total of 360 bones, 12 major joints in the limbs, and 210 minor joints. Due to the highly developed and complex nature of the human body's motion system, and the strong learning and innovation capabilities of humans, human actions and behaviors are exceptionally rich and diverse. Imitating human behavior in robots remains a challenging task with a long road ahead. Given the current limitations in materials, electromechanical systems, and intelligent control capabilities, this project can only study humanoid motions and behaviors in robots based on the motion characteristics of major human joints.

The seven major joints in the human body include the shoulder joint, wrist joint, hip joint, knee joint, ankle joint, elbow joint, and temporomandibular joint. There are twelve major limb joints, categorized as left shoulder, right shoulder, left elbow, right elbow, left wrist, right wrist, left hip, right hip, left knee, right knee, left ankle, and right ankle joints. Additionally, the neck, waist, eyes, face, and fingers are involved in frequent movements. These movements constitute the fundamental motions of the simulation robot. Due to the variations in the "four dimensions of motion" — dimension, speed, amplitude, and force — across these motion mechanisms, the selection of power, and the integration of mechanisms pose key challenges in the development of motion mechanisms.

In terms of power selection, considering the current technological level and factors such as cost-effectiveness, reliability, and compatibility, for mechanisms with high action frequency, fast speed, and low force, electromagnetic actuators can be chosen, such as for actions like blinking or eyelid movement, and similar activities. For mechanisms with small motion amplitudes, slow speed, high force, and heavy loads, servo motors, hydraulic or pneumatic actuators can be selected, especially for movements in knee joints, ankle joints, and similar locations. For general-purpose movements, servo motors are a preferred choice, as seen in neck and waist movements, for instance. Full-range speakers can be used as the audio source for dialogue.

In terms of mechanism integration, due to the requirements of behavioral norms, many motion mechanisms involve multidimensional actions. For instance, the shoulder joint needs to perform both lateral and anterior-posterior movements, as well as coordinated and independent motions. Consequently, the motion mechanisms of simulation robots must integrate components for different motion directions.

Additionally, due to the requirements of the "four dimensions of motion" and the limitations imposed by the human body's scale, there are stringent demands on structural dimensions, material strength, spatial utilization, and the arrangement of components for transmission, reduction, support, limiting, and retardation [11] within motion mechanisms. Therefore, in the design of simulation robots, a high degree of integration and rational decomposition are essential to construct scientifically and economically viable motion mechanisms.

## III. METHOD STUDY

### A. *Workflow of the Simulation Robot*

The simulation robot works on-duty 24 hours a day. To reduce energy consumption, it should automatically enter sleep mode after a suitable delay when there are no environmental anomalies and the work is completed. In sleep mode, the voice and motion platforms are deactivated, while the system host and mobile platform enter standby mode. Within the imaging platform, surveillance cameras are active, and environmental perception and system monitoring functions are enabled in the acquisition platform, while other functions are deactivated. In sleep mode, the acquisition platform can be triggered by detecting moving objects, unusual sounds, temperature changes, or vibrations, and external commands can directly awaken the system.

Upon waking, the system automatically enters a tracking and monitoring state. It searches for targets, calculates their spatial positions and motion parameters, issues motion commands to the motion mechanisms, adjusts the robot's posture to align its eyes and sensors with the target, allowing for activities such as photography, video recording, monitoring, vehicle recognition, facial recognition, and body temperature measurement. If necessary, it can engage in voice communication and human-machine interaction for verification purposes. Finally, based on the verification results, commands are issued to the motion and voice platforms for further action. Hence, the fundamental workflow of the simulation robot includes sleep mode→wake the system→tracking and monitoring →verification and action, as depicted in Figure 1.

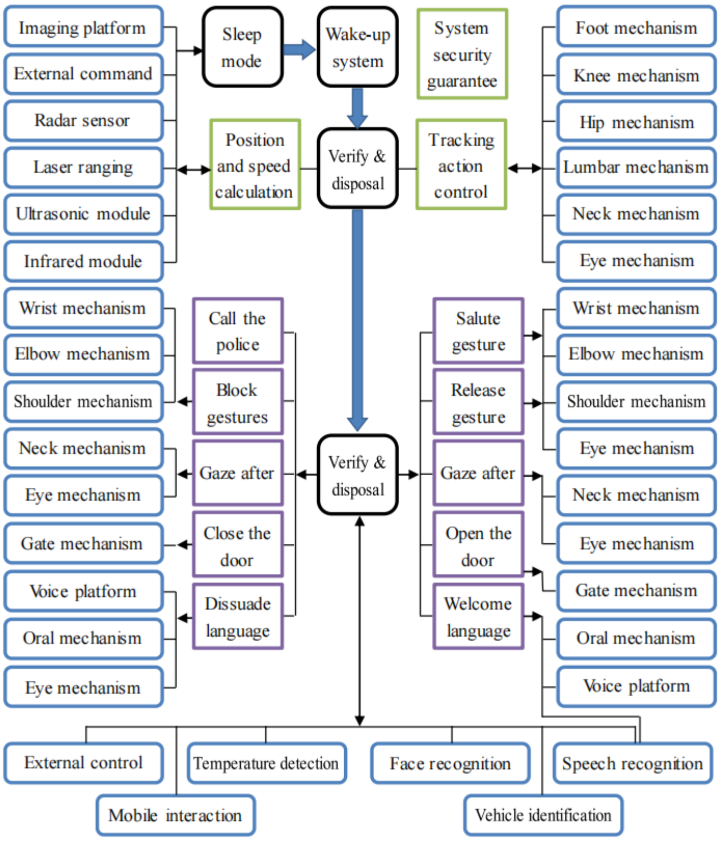


Figure 1: Basic Workflow Of Simulation Robot (Drawn by the Author)

### *B. Control Modes of the Simulation Robot*

The fourth industrial revolution is all about intelligence, and the rapid iterations in artificial intelligence will continue to spark the emergence of new technologies and products. Technologies and products such as Chat GPT, intelligent voice responses, and fast facial recognition are set to support the significant growth of simulation robots. In particular, GPT (Generative Pre-trained Transformer) is a large generative artificial intelligence language model based on deep learning and reinforcement learning with human feedback [12]. It has undergone extensive pre-training with massive data and can generate content-rich, human-like natural language text based on user instructions. Its computational power mainly comes from Microsoft's cloud computing service, Azure AI's supercomputing infrastructure [13], and it has virtually covered the entire internet. With its knowledge spanning a wide range of domains and strong capabilities in addressing common-sense and general knowledge questions, GPT can empower various fields like social interactions, marketing, and scientific research [14].Therefore, various sensor modules, imaging platforms, voice platforms, system hosts, and mobile platforms can opt for mature and advanced products and services, including algorithms such as image enhancement [15]. This not only reduces the development and manufacturing costs of the robot control system but also allows for timely updates to software and hardware components.

In addition, the basic movements of the simulation robot require over 70 terminal electromechanical devices for actuation. The control, feedback, verification signal lines, and power lines for these underlying devices range from several hundred to over a thousand. To conserve mainframe system resources, facilitate wiring layout, and enable functional expansion and updates, it is not advisable for the mainframe to directly control the terminal electromechanical devices. Therefore, the control system of the simulation robot should adopt a distributed structure, which is a three-tier hierarchical structure composed of the mainframe, platforms, and modules.

Based on the hierarchical structure described above, the mainframe primarily handles tasks such as external communication, remote interaction, remote storage, autonomous learning, complex computations, the establishment and retrieval of large databases, and issuing commands. In the context of motion control, the mainframe issues action commands rather than action parameters, let alone specific drive current, voltage, or frequency. The task of the motion control platform is to receive action commands from the upper computer, calculate specific motion parameters, generate accurate control signals, control internal drive ICs or external modules, and output specific current and voltage to the terminal electromechanical devices to execute the action commands issued by the mainframe. Additionally, to ensure the accuracy and safety of the actions, adjustments to motion parameters must be made promptly based on feedback from sensors, limit switches, and other information obtained by the collection platform during the execution of actions. The motion state should also be fed back to the mainframe.

### *C. Motion Platform of the Simulation Robot*

Human activities consist of behaviors, and behaviors comprise various actions that are carried out through the movement of tissues such as muscles. On one hand, actions can be broken down into components where decomposed actions involve a combination of time, space, and displacement. On the other hand, behaviors encompass several actions that require coordinated movements of multiple mechanical components to accomplish. Therefore, by planning and specifying the motion time, spatial displacement, and components of actions based on action standards, control over the actions can be achieved. Additionally, by creating action sequences according to behavioral norms, managing delays, connections, and transitions between actions, and setting parameters like the start, stop, speed, and amplitude of actions, action libraries and behavioral libraries can be established, providing support for the control of motion components.

The motion control platform developed in this project utilizes the STM32F407ZET6 chip, capable of directly driving 12 servos (compatible with 12 stepper motors) and controlling 15 terminals through digital input, 6 terminals through pulse-width modulation (PWM), and 3 terminals through opto-isolation. This platform can control a total of 36 terminals. Additionally, it features 16 analog input channels and analog-to-digital conversion capabilities. Communication with the main controller and other platforms is achieved through CAN, USB, RS232, and RS485 interfaces. The platform includes functions such as reference voltage generation, self-temperature diagnostics, and additional storage.

This platform offers excellent versatility and is suitable for controlling various robots and CNC (Computer Numerical Control) devices. In cases where there is a shortage of control channels, additional instances of this platform can be added. By implementing a master-slave or parallel distribution, it forms a "small centralized +

large distributed" structure, as depicted in Figure 2. In this project, two motion platforms are employed, each responsible for controlling the upper and lower body motion mechanisms of the simulation robot.

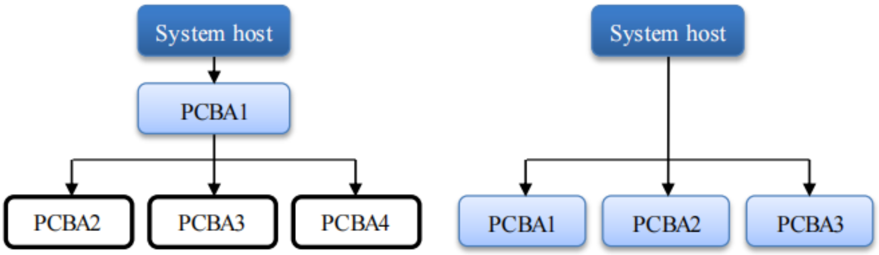


Figure 2: Schematic Diagram of the Composition of the Action Platform (Drawn by the Author)

## IV. EMPIRICAL RESEARCH

### *A. Basic Structure of Simulation Robots*

The project team used stainless steel sheets to create the main structure of the mechanical part through cutting, bending, and welding. They fabricated the motion mechanisms using self-made servos, geared motors, bearings, gears, and other components. The robot's body was made from materials like silicone, and a full set of security uniforms was purchased for the robot's attire. This completed the development of the mechanical part of the simulation security robot, achieving a highly lifelike human appearance. The arrangement of its body, main motion mechanisms, and control system hardware can be seen in Figure 3, and the primary motion mechanisms and their functions are described in Table 1. The structure and control flow of this simulation robot are detailed in the invention patent "A Multi-Functional Robot and Its Workflow," with patent number ZL 201810997286.3.

Table 1: List of Partial Motion Mechanism Functions

| Code | Function |
|---|---|
| DM1 | Eye movement up and down |
| DM2 | Eye movement left and right |
| DM3 | Left eyelid movement |
| DM4 | Right eyelid movement |
| DM5 | Mouth movement up and down |
| DM6 | Horizontal shaking of head |
| DM7 | Head swinging left and right |
| DM8 | Head swing back and forth |
| DM9 | Left arm swing back and forth |
| DM10 | Right arm swing back and forth |
| DM11 | Left arm swinging left and right |
| DM12 | Right arm swinging left and right |
| DM13 | Left arm rotation |
| DM14 | Right arm rotation |
| DM15 | Left elbow bending movement |
| DM16 | Right elbow bending movement |
| DM17 | Left elbow rotation |
| DM18 | Right elbow rotation |
| DM19 | Left wrist bending movement |
| DM20 | Right wrist bending movement |
| DM21 | Horizontal rotation of the waist |
| DM22 | Bend the waist back and forth |
| DM23 | Bend the waist left and right |
| DM24 | Left leg movement forward and backward |
| DM25 | Left leg movement left and right |
| DM26 | Left leg rotation |
| DM27 | Left knee bending movement |
| DM28 | Left ankle vertical rotation |
| DM29 | Left ankle horizontal rotation |
| DM30 | Left toe movement |
| DM31 | Right leg movement forward and backward |
| DM32 | Right leg movement left and right |
| DM33 | Right leg rotation |
| DM34 | Right knee bending movement |
| DM35 | Right ankle vertical rotation |
| DM36 | Right ankle horizontal rotation |
| DM37 | Right toe movement |

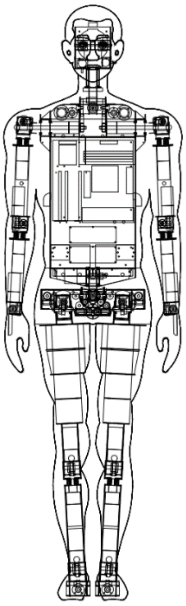


Figure 3: Basic Structure of Simulation Robot

In the control system, the main host is assembled using components such as the B460M MORTAR WIFI motherboard, an I5-10400CPU, 8GB DDR4 RAM from HyperX, and a 512GB solid-state drive (SSD) from HyperX. The imaging platform utilizes products and services from Hikvision, while the speech platform uses products and services from iFlytek. A Huawei X40 smartphone is selected for mobile platform use. The data collection platform is composed of products such as the RCWL-0516 radar module, MPU6050 module (integrated with a three-axis accelerometer and a three-axis gyroscope), DHT11 temperature and humidity module, raindrop sensor module, and a PCBA developed by the project team (with the STM32F407ZGT6 chipset). The safeguard platform and motion platform are developed by the project team, as described earlier.

The host is installed inside the chest cavity, and the hardware layout of the host and action platform is shown in Figure 4. After dressing up, the photo is shown in Figure 5, and the salute action is shown in Figure 6.

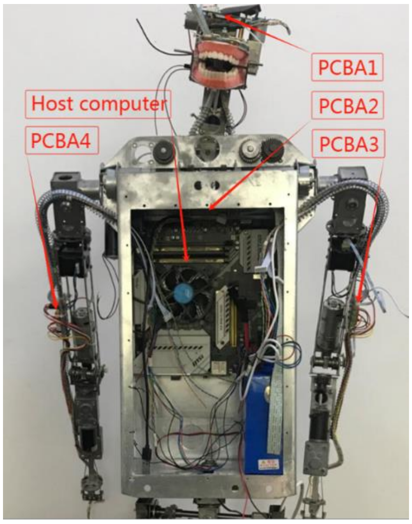


Figure 4: Upper Body Structure

### *B. Motion Testing of the Simulation Robot*

For the empirical research scenario in which the simulation robot serves as a security guard in the residential community, the robot's actions during the process when homeowners walk into the community are as follows:

Step 1: The simulation robot is awakened by the approaching individual and automatically turns to face the homeowner, initiating facial recognition.

Step 2: After completing identity recognition, the simulation robot autonomously salutes the homeowner, instilling a sense of security and satisfaction.

Step 3: The robot opens the pedestrian gate to allow the homeowner to enter the community, bids them farewell with "Please proceed," and observes as the homeowner enters.

Step 4: After ensuring there are no unusual circumstances around the gate and waiting for a 10-second delay, the robot enters sleep mode automatically.

Figure 5: Photos after Dressing Up

Figure 6: Salute Action Photo

In Step 2, if facial recognition fails, the simulation robot will engage in active communication with the homeowner. For example, it might ask, "Which building are you from? In which unit do you reside?" This verbal interaction serves as an additional means of identification and verification. Additionally, if someone had come to visit the homeowner, if there's a delivered package for the homeowner, or if there are community notifications to convey to the homeowner, the simulation robot will actively engage in communication and interaction.

In Step 3, for individuals not allowed entry, the simulation robot will not grant access and may use verbal communication to encourage them to leave. In cases of violent intrusion, the robot will promptly sound an alarm and capture detailed images and behavioral characteristics of the intruder.

In the empirical experiment, the operating status of the system was observed through an external display, and the main program running monitoring window is shown in Figure 7. The modification and monitoring window of action parameters is shown in Figure 8. Following testing, the control system's external and internal communication functions are working correctly, and the upper body and neck movements are generally well-coordinated. However, there is room for improvement in the completion of waist, hip, and lower limb movements. After conducting a comparative analysis with existing literature [16-17], several main reasons for this have been identified:

(1) The presence of significant loads, such as gravity, has placed a strain on the motors due to inadequate power.

(2) High friction in the transmission and reduction mechanisms has led to reduced transmission efficiency.

(3) Issues related to inertia, shock absorption, energy storage, and energy consumption have not been adequately addressed.

(4) The rapid balance technology has not achieved the expected results.

(5) Movement standards and gait planning are not yet well-refined.

(6) There are still several issues with data structures and algorithms.

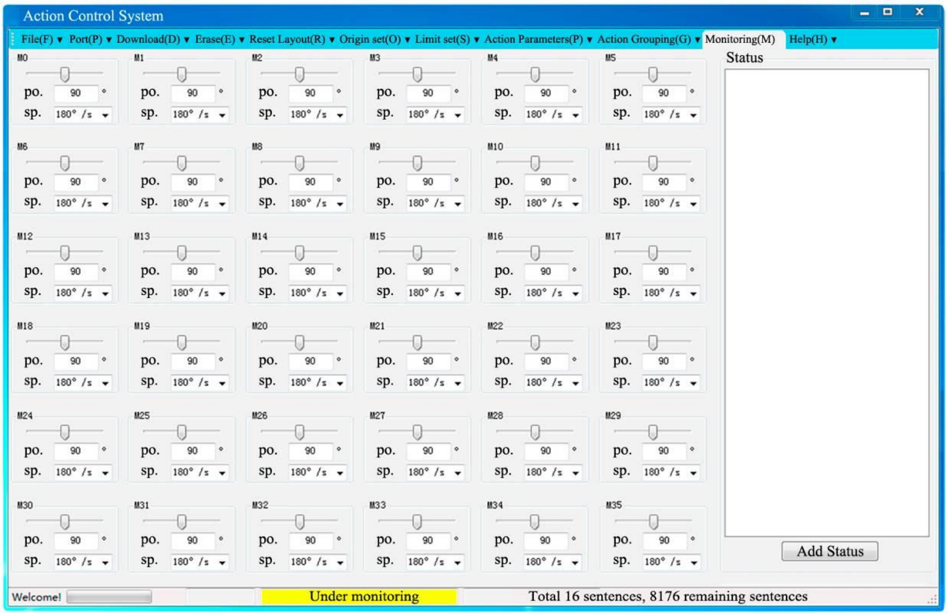
Power Input AC223
Battery Level 100mAh
Power DC24V 24V/10A
Power DC12V 12V/15A
Power DC5V 5.1V/1A
Power DC3.3V 3.4V/1A
Online Power 100W
Internal TEMP 20.5℃
Internal RH 78%
Torso Posture +1
Head Posture -10
Vibration NRM
Force on Head NRM
Shoulders NRM
Left Hand NRM
Right Hand S. P.
Waist NRM
Force on Feet NRM
External TEMP 20.5℃
External RH 80%
Brightness LTG
Body Humidity Damp
Communication Online

2023. 11. 11 11:30:30

Target 3 pedestrians
Speed 5km/h
Distance 10m
Azimuth Left front 10.5°
Validate Insiders

Head Turning Left
Eyes Opening
Mouth Shut up
Neck Stall
Left SH. Stall
Right SH. No Action
Left Elbow No Action
Right Elbow No Action
Left Hand Not in Place
Right Hand No Action
Waist No Action
Hips No Action
Knee No Action
Foot No Action
Barrier Gate Closed
Lighting Closed
Aux. Camera In Progress
Cloud Save In Progress
Tar. Tracking In Progress
Facial Rec. In Progress
Vehicle ID In Progress
Temp. Det. In Progress
Voice Res. In Progress

Figure 7: Screenshot of Main Program Running Monitoring Window



M0 po. 90 ° sp. 180° /s
M1 po. 90 ° sp. 180° /s
M2 po. 90 ° sp. 180° /s
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M30 po. 90 ° sp. 180° /s
M31 po. 90 ° sp. 180° /s
M32 po. 90 ° sp. 180° /s
M33 po. 90 ° sp. 180° /s
M34 po. 90 ° sp. 180° /s
M35 po. 90 ° sp. 180° /s

Welcome!
Under monitoring
Total 16 sentences, 8176 remaining sentences

Figure 8: Screenshot of Action Parameter Settings and Monitoring Window

These areas will need to be addressed and improved in order to enhance the performance of the control system. The "movement characteristics of the simulation robot require the driver to have characteristics such as high power density, high responsiveness, high energy efficiency, and impact resistance, among others. It is expected to approach or even reach human-level movement performance, but current robots like Honda's ASIMO, Boston Dynamics' ATLAS, or the Italian Institute of Technology's Walk-Man are far from achieving the movement performance of humans or animals"[18]. Given this, the current solution is to disable the walking functions of the simulation robot. Since the simulation robot developed in this project primarily handles tasks related to security, promotion, consultation, communication, receiving and sending, and collection of fees, its inability to walk does not significantly impact these functions.

## V. CONCLUSIONS

The main research conclusions of this article are as follows:

(1) The simulation robot can serve the construction of safe communities, and can undertake some tasks such as security, publicity, consultation, communication, sending and receiving, and charging. It has good economy, safety, practicality, and necessity.

(2) Due to its highly imitative appearance and behavior, the simulation robot can not only engage in simple communication and interaction with humans, but also have a good sense of social presence and interaction affinity. It can also produce a good sense of deterrence against illegal and irregular personnel.

(3) Empirical research has shown that in order for the actions of simulation robots to conform to human behavioral norms, further research is needed, especially in terms of the power and control technology of lower limb motion mechanisms, which still have many problems, which is also the shortcomings of this project.

The innovation of this project lies in: firstly, through the optimization of structure, mechanism, and materials, the simulation robot has achieved a high degree of imitation of humans in appearance, speech, and behavior, with a good sense of social presence and interactive affinity; The second is to apply the simulation robot to the construction of safe communities, which can reduce the risk of infection of security guards, property management and other personnel in response to public health events such as the COVID-19.

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