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Development Report:

System Integration for Component-Based Manzai Robots with Improved Scalability

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This paper describes system developments for integrating control systems of Manzai robot duos that automatically generate Manzai scripts from Internet articles based on given keywords, as well as improvements in the scalability of the integrated control system. Component-based Manzai robots controlled by RT-Middleware have been developed. However, conventional Manzai robot systems, the control systems of which are individually developed, experience some difficulties in interface integration and system maintenance as well as in scalability. In this study, we built a Manzai robot system excellent in reusability, maintainability and scalability by separating the common part from the hardware-dependent part by using the RT components of RT-Middleware. We also verify the reusability and scalability of the hardware-constrained component groups by implementing the Manzai robot control system into ready-made robots with different types of mechanism. We proved the effectiveness of the developed Manzai robot control system on its implementation results.

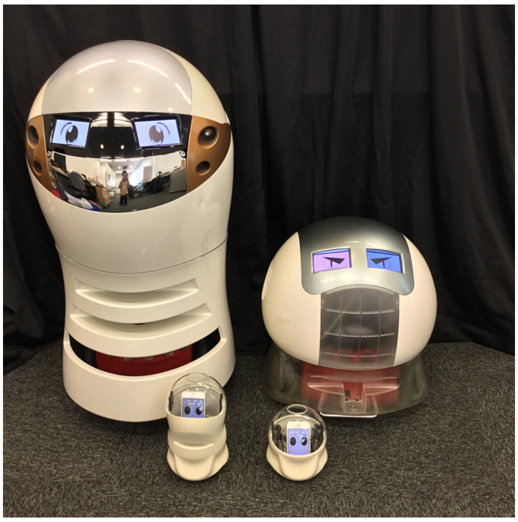

Fig. 1. Manzai robot duo. Left: Robot ii-1 is called "Aichan"; right: Robot ii-2 is called "Gonta" in the demonstrations in the exhibitions.

Keywords: Manzai robots, RT-Middleware, system integration

1. Introduction

In this aging society, with changes in the social structure, improving the quality of life, especially that of older people by securing their communications, is essential. Therefore, there is a need for developing a wide range of communication robots designed for smooth communication [1, 2]. The purpose of such communication robots could be achieved by activating human-robot interactions. In this sense, studies have reported that people who have observed dialogues between robots can make more natural and smoother communications with robots [3]. Based on the studies on the automatic generation of dialogues by agents [4, 5], we developed Manzai robots to promote entertainment-based dialogue observations as social passive media and overcome news aversions by incorporating current affairs [6].

Currently, there are several ongoing studies on robots that perform Manzai using two bodies of communication robots, for example, those that considered Manzai robots as passive media [7] and studies focused on the robot's motions for Manzai performance [8, 9]. On the other hand, we focused on generating Manzai performance scripts to develop Manzai robots so that they can function as communication media [10, 11]. We have so far developed two types of Manzai robots, as shown in **Fig. 1**, to allow for some space in performance according to the scenes [6, 12].

This paper describes system developments for integrating control systems of Manzai robot duos that automatically generate Manzai scripts from Internet articles based on given keywords [13]. Small component-based Manzai robots controlled by RT-Middleware [14] have been developed [12, 15]. In addition, in the conventional Manzai robot systems, the control systems are individually developed, and the control system for a large Manzai robot duo is developed as a single program. The use of a different system from that used for the small Manzai robot duo has caused some difficulties in their interface integration, system maintenance, and scalability.

In this study, we used the RT components of RT-Middleware [14] to implement the common and specific parts as separate RT components and apply the components in the common part to both Manzai robot systems. We created the components based on the performance of the Manzai scripts so that they can flexibly adapt to any additional performances. The user interfaces for operating the robots are implemented as a common Web application so that the interfaces can be integrated and the robots can be operated on the networks.

In this study, we incorporated the proposed control framework into ready-made communication robots to function as a Manzai robot duo. Umetani et al. [12] confirmed the scalability of the Manzai robot control system by illustrating the modified mobile robot carriage. In this study, we applied it to robots with different types of mechanisms and distinctly separated it into parts that depend and do not depend on the robots' hardware to prove the scalability and flexibility of the proposed control system. We also verified the reusability and scalability of the component groups by considering their hardware constraints to prove the effectiveness of the proposed techniques on their implementation results.

2. Control System Designs for Manzai Robots

This section describes the control-system designs for Manzai robots. We first present the hardware configurations for these robots that have been individually developed, and then describe the designs of the control system and their extensions.

2.1. Hardware Configurations for Manzai Robots

We developed multiple Manzai robot duos, each of which performs Manzai through two robot bodies: one as a stooge (boke) and the other as a straight man (tsukkomi). In performing Manzai, they utter their dialogues, change their expressions, move or rotate on the spot in line with the contents of automatically generated Manzai scripts. **Fig. 1** shows the large and small Manzai robot duos. The large Manzai robot duo [6] consists of robots with heights of approximately 1000 mm (ii-1) and 500 mm (ii-2), and the same breadth of approximately 500 mm. With their eyes functioning as liquid crystal displays, they can create different expressions by switching their eye displays with the Web browser. The integrated control computer used for the large Manzai robot (ii-1) was mounted on Robot ii-1. The computer to control Robot ii-2 was mounted on the robot itself.

In contrast, the small Manzai robot duo [12] consists of Robots ii-1 and ii-2 with heights of approximately 250 and 150 mm, respectively, and the same breadth of approximately 150 mm. They use Pololu Zumo 32U4 as their carriage, and their control computers with Raspberry Pi A+ are stored in their bodies. They are controlled by the RT component system of the previously developed desk-type component-based robots [16]. They can perform different expressions by switching the facial expressions displayed on the iPhone display. We used a laptop PC as the integrated control computer, and each robot is controlled by Raspberry Pi mounted on it.

2.2. Control-System Designs for Manzai Robots

The control systems for Manzai robots, though developed for mainly "performing Manzai," have different hardware constraints and are implemented individually. In such cases, their operations become more complicated, and the limited number of personnel who can operate such robots has made the improvement of the performance of new hardware parts more difficult. Therefore, in this study, we integrated the control systems of the Manzai robots according to the following policies to develop a new Manzai robot system [13].

1. Limit the dependence on OS or hardware to a minimum.
2. Reduce the communication traffic volume and calculation amount between systems during a Manzai performance.
3. Integrate the interfaces in the operation part.
4. Make a part of the system executable with a computer different from that used for the robots.
5. Conduct RT componentization according to the performance.

These policies are described in more detail as follows. The large Manzai robot duo operates entirely in the Windows environment, while the small Manzai robot duo has two types of OSs, Windows and Debian, and different robot hardware. If a control system is dependent on an OS or hardware, some components that are reusable in a certain system may not be reusable in others. Furthermore, any system modifications, such as system maintenance, additional functions, and additional performances, may not be implemented in other systems. In addition, such modifications would need to be implemented in every system. Therefore, we divided the OS- or hardware-dependent parts into small function components as much as possible, for example, "communicate with the hardware." Furthermore, the above-mentioned problems can be resolved by componentizing the parts that are not dependent on the OS or hardware into common components.

Next, the communication traffic volume and calculation amount between systems were suppressed during a Manzai performance. In a Manzai robot system, both robots are connected via a wireless LAN. In some exhibition halls with a large number of visitors, the presence of multiple communication equipment hinders the communication in normal Manzai performances [15]. In addition, when large-volume data, such as voice data, are sent or when heavy-loaded calculations, such as voice synthesis,

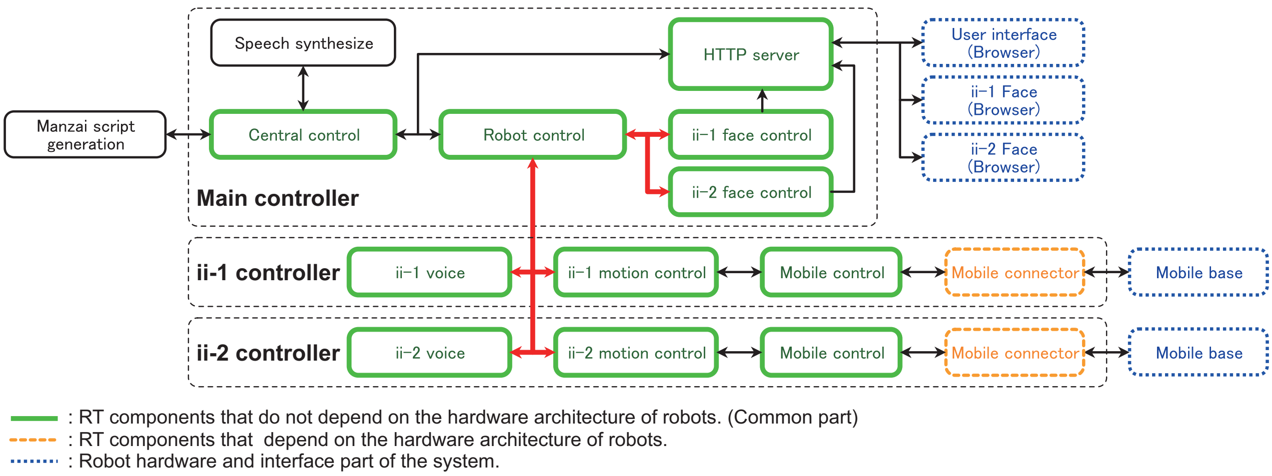

Fig. 2. System configuration of Manzai robot control system [13].

are conducted during the Manzai performance, they lead to time delays. We mitigated the above-mentioned problems by reducing the communication-traffic volume and the calculation amount between systems during a Manzai performance [12]. In developing the proposed system, we followed the policies described in a previous report [12] and completed the communications required for Manzai performance and calculations required for voice synthesis as much as possible prior to Manzai performance. Further, we suppressed the communication-traffic volume and calculation amount by transmitting data to each control PC in advance and by mutually communicating progression chords only during a Manzai performance.

We also integrated the interfaces in the operation part. As the conventional Manzai robot control systems are individually developed, the interfaces to control respective Manzai robot systems are different from each other. In addition, as individual Manzai robots require different preparations for their performances, such as their file operations, Manzai performers sometimes make operating mistakes, hindering their performance. To cope with such problems, we developed the interfaces in the operation part along with all their accompanying functions as common components and integrated their operations.

Next, we made a part of the control system executable with a different computer than that used for the robots. Regarding the control system for the small Manzai robots, their calculation resources incorporated into the robot body are too limited to operate their entire control system. Executing part of the control system with a different computer enables the control system to be operated without depending on the calculation resources incorporated into the robot body.

Finally, during the implementation of the control system, Manzai software is componentized according to the performance. Any Manzai performance involves various motions, such as changes in expressions and movements. Till date, large Manzai robot systems have been managed by a single control program. Similarly, in conventional small Manzai robot systems, a single component, in some cases, has managed plural performances. In such situations, any additional performances have made their programs and components vague. As the robots are so designed as to be able to realize all performances, they cannot disable any performances. Therefore, the performance-based componentization will enable the components to be managed according to the performance and will facilitate in performance management and addition of any new performances. Moreover, acts that cannot be performed by any specific robots can be disabled.

In this paper, to prove the scalability of the Manzai robot system, we describe the development of a Manzai robot system for a heterogeneous robot, PaPeRo i. The two types of robots described earlier have different types of hardware but the same functions. In contrast, PaPeRo i, as a ready-made communication robot, differs according to the presence of a mobile mechanism, facial expression methods, and the uttering function. In this study, we built a Manzai robot control system by reusing multiple components, determining their dependence on hardware constraints, and proving the scalability and usefulness of software-component-based Manzai robots.

3. Built Manzai Robot System

In this section, we describe how we build a Manzai robot system. First, we overview the Manzai robot control system, then present the designing of its interface, and finally refer to the robot control framework based on its Manzai scripts.

3.1. Control System for a Manzai Robot Duo

Figure 2 shows the system configurations for the Manzai robot control system that we developed. The arrows in the figure indicate data exchanges: the thick arrows indicate the communication common between the performance components. Prepared for each performance part, these arrows indicate the control commands independently transmitted according to the progress of a performance. The dashed blocks indicate the RT components dependent on the hardware; the thick blocks indicate the RT components common between large and small Manzai robots; and the dotted blocks indicate the external hardware and software.

- Central control: This is the integrated control part in the Manzai robot control system. It executes programs for script generation and voice synthesis and is driven by the interface operation.
- Robot control: Controls the robots performances and generates separate control commands for a robot's carriage, voice, and facial expression parts. Robot control is created according to the performance type.
- Face control: Switches the facial-expression-displaying pages on the control commands from the robot control part.
- Voice: Utters voices on the control commands of the robot control part.
- Motion control: Generates control commands for the robot carriage based on the robot control.
- Mobile connector: Communicates with an actual robot carriage to control it.

'Speech Synthesize,' and 'Manzai Script Generation' are the external programs used to synthesize voices and generate Manzai scripts, respectively. Furthermore, the servers for facial expressions and interfaces are controlled by the HTTP server. The Python version of Open RTM-aist 1.1.2 was used for the software environment and common RT components were implemented for the common purpose of "performing Manzai."

The control unit of the robot carriage, which is hardware, implements RT components so that the software functions are least duplicated. Specifically, separate RT components were created for communicating with large and small Manzai robot carriages, i.e., Pioneer 3-DX and Polulu Zumo 32U4, respectively; these components only have the function of communication. In addition, independent RT components were implemented to manage the performance of the robot carriage and determine the carriage's control input.

With the aforementioned development method of the Manzai robot control system, the RT components in the performance management part can be treated as those in the common part. As a result, when implementing the Manzai robot system into a robot with no carriage, the performance management part can be utilized as is, so that the carriage control unit has less dependency on the OS or hardware.

3.2. User Interfaces

We implemented the terminals to display user interfaces by using HTTP and Web Socket servers so that they do not need to depend on an OS or hardware. In addition, we implemented these servers as RT components in the common part. Then, any PC, smartphone, or tablet terminal that can use Web browsers compatible with Web Socket and JavaScript can operate the robots by connecting them to the same network. In addition, as the HTTP and Web Socket servers are implemented in the common part, comprising the components to process the signals from the user interfaces, every Manzai robot duo can use the same user interfaces.

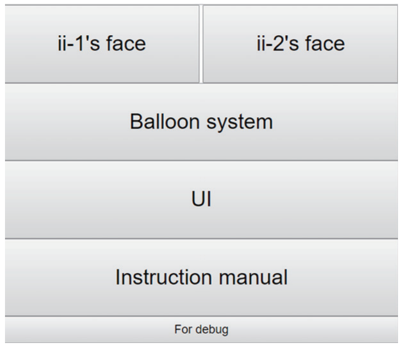

Fig. 3. Screenshot of user interface of Manzai robot system.

The following functions were implemented in the user interface.

- Preparing for a Manzai performance.
- Starting/stopping a Manzai performance.
- Connecting/disconnecting communications to the carriage.
- Displaying expressions or balloons.
- Manually control of the carriages and expressions.

Moreover, the eyes and expressions were displayed through the Web browser. When the dedicated pages are opened, image data for the eyes and expressions are transmitted to the all browsers and are switched to those required for a particular performance; thus, we can suppress the communication-traffic volume during a Manzai performance. As we use the same HTTP and Web Socket servers similar as used for the user interfaces and they are implemented in the common part, the control unit required to display the expressions does not depend on the OS or hardware.

Figure 3 shows a screenshot of the generated user interface, where "ii-1's face" and "ii-2's face" show the respective robots' facial expressions. In addition, the "Balloon system" button displays the pages of the balloon display system; "UI" constitutes selective interfaces, such as individual control of the Manzai robot duo and script generation. During an actual Manzai performance, the interfaces are displayed on a tablet terminal. The expressions of the small Manzai robot duo can be displayed by transitioning them from the user interface. Thus, we realized the user interfaces that do not depend on OS or hardware and suppressed the load on the network to display expressions.

3.3. Control of the Robot Duos on Manzai Scripts

Manzai scripts written in the XML format contain the data for Manzai performance [4, 10]. The XML scripts are generally used to control the scenarios for the network robots or motion of the media robot systems [17, 18]. The XML tags containing the data for Manzai performance are provided at the same time as the automatic generation of Manzai scripts. As there is a tag dedicated to each performance in the XML file, we specify its performer through the attributes of each performance. In synthesizing voices in the speech-utterance part of the script, the synthesized voice data are embedded in the XML file so that voice data as well as scripts are transmitted, obviating any need to provide a separate function to transmit voice data.

As voices are synthesized in advance, no time delays due to voice synthesis or its transmission will occur at the time of Manzai performance. To reduce the communication-traffic volume during a Manzai performance, script data with embedded voice data are transmitted prior to Manzai performance. The XML-file contents are delivered in XML strings to each component by using the communication function of the RT-Middleware between components.

In delivering a script, all its contents are delivered to every performance component. The component that receives a script retrieves the required performance contents and the IDs for the lines corresponding to the said performance while disregarding the rest. As the data exchanged during a Manzai performance are limited to the IDs allocated to the script lines and signals indicating that the performance component has finished its performance, the communication-traffic volume during a Manzai performance can be significantly reduced. In addition, if any tags irrelevant to the performance are specified, every performance component ignores such tags so that even metadata can be embedded in the script. A new act can simply be added by connecting to the component that creates the component for the added performance and delivers its script.

As the performance components for the large and small Manzai robot duos are common, the RT components that control the entire Manzai robot system also become common, and thus we can integrate multiple systems. **Table 1** shows the performances that are common among the Manzai robot systems described in this paper. Balloons are displayed to visualize the speech contents and Web pages are generated in accordance with the progress of the script [12]. Balloons can be viewed through an external Web browser to visualize the speech contents. The robot duo performs Manzai by combining the functions for delays, expressions, carriage, and utterances; the motions that each robot performs according to the contents of the Manzai scripts.

The system construction based on the carriage operation and components in the communication part was observed to improve the scalability of performance during a Manzai act. The suppression of the communication-traffic volume during a Manzai act to reduce the OS- or hardware-dependency improved the flexibility of the execution of the control system.

Table 1. Performance implemented in Manzai robot control system.

Function	Purpose
Display of balloons	Visualize speech contents
Delay	Create a pause Waiting for a straight touch of speech
Expressions	Changes of expressions
Carriage	Perform moving, rotating and other motions
Utterance	Utter dialogues

Fig. 4. Manzai robot duo using PaPeRo i robots.

4. Extending a Manzai Robot to Robots with Different Mechanisms

In this section, we describe the development of a Manzai robot system for use as a different type of robot, PaPeRo i [a], to prove its scalability. By considering the dependency on hardware constraints, we built a Manzai robot system by reusing multiple components.

4.1. Development of Manzai Robots with PaPeRo i

Figure 4 shows the PaPeRo i that was used in this study to develop a Manzai robot system. **Table 2** shows its comparison with the existing Manzai robot configurations. Unlike the large and small Manzai robot duos, PaPeRo i has no moving mechanism, although it can rotate its head. PaPeRo i presents its expressions using the LED lamp embedded in its head and utters voices with the utterance function installed in its body. In addition to the robot itself, the hardware consists of only a laptop PC as a controller.

As shown, PaPeRo i differs significantly in hardware configurations from the conventional Manzai robot duos. In consideration of the parts dependent on the hardware constraints, we implemented the Manzai robot system into PaPeRo i under the following policies so that we can reuse multiple components for the system construction.

1. Reusing the existing components developed for the purpose of "performing Manzai."

Table 2. Hardware configurations for Manzai robots.

	Large	Small	PaPeRo i
Mobile carriage	Available (Pioneer 3-DX)	Available (Zumo 32U4)	Unavailable
Head rotation	Unavailable	Unavailable	Available (pitch, yaw)
Display of expressions	Display images on eye LCDs	Display facial images on iPhone	Light head LED
Speaking method	SAPI or AITalk (Kansai dialect)	AITalk (Kansai dialect)	Incorporated into robot
Calculation resources	2 laptop PCs	1 laptop PC, 2 Raspberry Pi	1 laptop PC

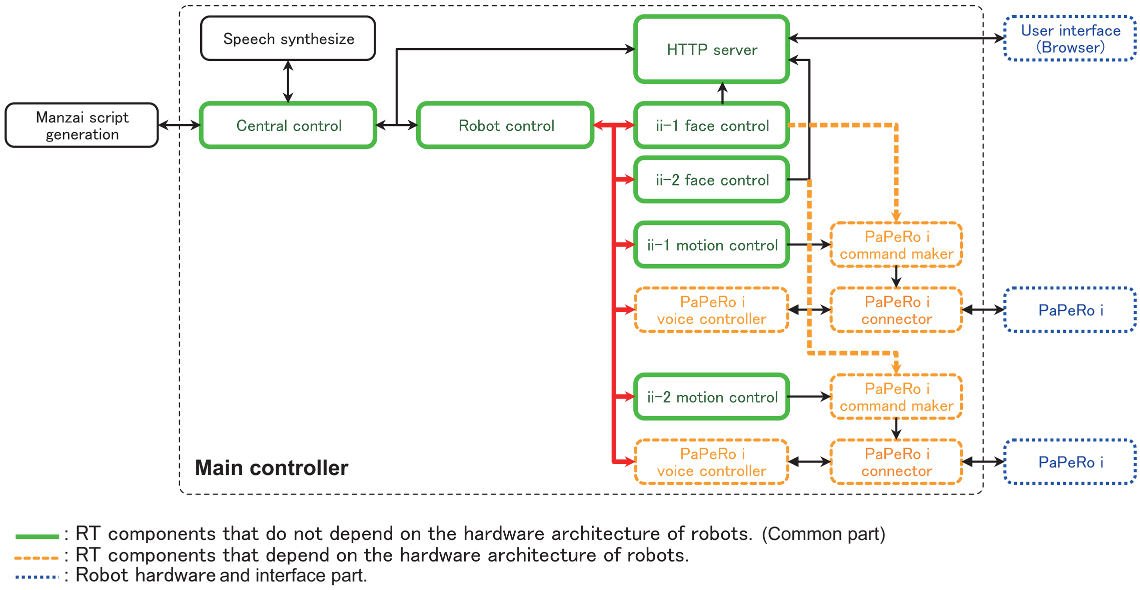

Fig. 5. System configuration of Manzai robot system for PaPeRo i. RT components on the main controller are executed on PC.

2. Separating the components used for communicating with the robot from those used for generating commands.
3. Canceling no parameters for the utterance voice quality.

We reused the existing components developed for "performing Manzai." This is because the implementation of a different system in the robot would cause some problems with its maintenance and operation as in the case of the large and small Manzai robots. We also reused the operation of the user interfaces implemented in the common part.

Next, we separated the component used to communicate with the robot from that used to generate commands. The robot could be more easily controlled by enabling just one component to communicate with PaPeRo i and by enabling the robot to be operated for plural performances. As the control component is separated from the component to generate commands, any new performances can be simply implemented by developing a component to generate the robot's control commands.

No parameters are disregarded for the utterance of voice. As utterances to express feelings, etc., play an important role in Manzai performance, reading any script aloud by ignoring the voice quality performance would cause the performance to lose data. Therefore, the parameters for the voice quality to be considered by the robot's utterance system are converted into forms corresponding to the robot's voice quality.

4.2. Control-System Construction

Figure 5 shows the control system configurations of the Manzai robot for PaPeRo i. The arrows in the figure indicate the data exchanges: the thick arrows indicate the communications common with the performance components and the dashed arrows indicate other communications to incorporate the Manzai robot control system into the existing systems. Further, the dashed blocks indicate hardware-dependent RT components corresponding to the components dependent on PaPeRo i; the thick blocks indicate the RT components common with the Manzai robots, all of which used are the same as those used in the existing system.

Here, we describe the RT-component groups we have newly developed.

- Voice controller: Control the voices that PaPeRo i utters in accordance with the script performance.

- Command maker: Receive control instructions for the facial expression and motion-command generation parts and control the motion commands for PaPeRo i accordingly.
- Connector: Transmit commands to the actual PaPeRo i for the control orders generated in the voice-controller and command-maker units and control it.

As the robot duo performs facial expressions through the LED embedded in the head, we inputted the control orders to switch the facial-expression generation unit into the command-maker unit.

Reuse of the existing components enables us to reuse the interfaces for the Manzai-script generation system and voice synthesizer that have been used in the conventional Manzai robot control system. In addition, reuse of the components to manage expressions and motions enables PaPeRo i to perform Manzai by just implementing them into the robot. We developed the Manzai robot control system by using the Python version of OpenRTM-aist 1.1.2 so that the developed system is not dependent on the OS.

4.3. Performance of Motions and Expressions

The XML file used for Manzai performance comprises the definitions of every performance of motions and expressions. The Manzai robot control system transmits signals to other components to be in a state corresponding to the defined performance names. Specifically, PaPeRo i can perform motions and expressions by controlling the lamp for its head motions and expressions to correspond to the respective names. The signals to be transmitted are converted into the commands to control PaPeRo i.

We separated the component used for issuing commands from that used for managing performance or communicating with PaPeRo i. As such, we can reuse the performance-management component according to the performance; we do not need to provide a special part to the component to communicate with PaPeRo i. Hence, no special implementation is required. In addition, any new performance to be managed only based on its name can be easily implemented. In addition, any performance that cannot be managed based on only its name can be implemented by integrating a performance component with the function for creating commands to control each such performance, thus not impacting other performances. As discussed earlier, the performance of PaPeRo i for motions and expressions can be implemented without tampering with the system's scalability.

4.4. Utterance Performance

The utterance component in the XML file to be used for Manzai performance contains data for controlling the voice quality, such as the rise and fall in tone, as tag attributes. As utterance is the most important part in a Manzai performance, such data should be used as much as possible; therefore, the above-mentioned tag attributes must be used in implementing the utterance commands for the utterance performance.

To realize the above-mentioned implementation of utterance commands, we implemented a new utterance component without reusing the utterance-management component. The new utterance component creates utterance commands including data for the voice quality and transmits them directly to the RT component used for controlling the robot; this enables us to control the robot by considering its voice quality as well as eliminating the need for any special software implementation in the RT component to communicate with PaPeRo i.

5. Discussions

We proved the scalability and flexibility of the developed Manzai robot control system based on its implementation results. By dedicating a Manzai performance component to a type of performance, the system's scalability for Manzai performance was improved. All the scripts in the XML script file were delivered to every component so that each component only needs to acquire necessary performance scripts from the file, and any additional performance only requires us to create a new component. In addition, delivering the XML scripts containing voice data to each component prior to Manzai performance enabled us to obviate the need for a voice-data delivering system and suppress the communications involved in Manzai performance in the same way as in our previous report [12].

Table 3 lists the types and numbers of Manzai robot systems we developed in this study. Several RT components of the same type were used because they represent general-purpose components connected to the servers and for performance, and because the Manzai robot duo comprises two robot bodies. For example, when the large Manzai robot duo performs Manzai, it executes the RT component groups used in common with all Manzai robots, common with the large and small Manzai robot duos, and only needed by the large Manzai robot duo. **Table 3** also lists the items and numbers of respective RT component groups. For example, the central control RT component group used in common with all Manzai duos executes eleven RT components of the six types.

As shown in **Table 3**, RT components for the control system and performance control are included in the RT component group used in common with all the Manzai robot systems. Compared with the conventional Manzai robot control systems, the developed control system, in which any additions or modifications to the script performance control are reflected in all the Manzai robot duos, can facilitate its control system maintenance as well as easily add new types of performances. Furthermore, as the parts in which the RT components differ from the respective Manzai robot systems are hardware-dependent, the dependency between components decreases more than that in conventional component-based Manzai robot systems; this enabled us to incorporate the Manzai robot control system into existing robots. The use of general-

Table 3. Number of RT components for each Manzai robot control system.

Type of Manzai robot duo	Num. of RTCs	Items of RTCs	Num. of RTCs
For all Manzai robots	9 types, 16 components	Central control Performance control	6 types, 11 components 3 types, 5 components
For large and small Manzai robot duo	4 types, 10 components	Motion control Blinking eye	3 types, 8 components 1 type, 2 components
For large Manzai robot duo	8 types, 16 components	Voice using SAPI Motion base	2 types, 4 components 6 types, 12 components
For small Manzai robot duo	2 types, 4 components	Voice using AITalk Motion base	1 type, 2 components 1 type, 2 components
For PaPeRo i Manzai robot duo	5 types, 10 components	Performance generation	5 types, 10 components

purpose and common components has enhanced the system's reusability, proving the flexibility and scalability of the developed Manzai robot control system.

The integrated interfaces and Manzai robot control systems have eased the familiarization with the system so that any people other than system developers can stably operate the robots for Manzai performance irrespective of their types. People other than the developers can operate Manzai robots for performances in various scenarios: for example, events attended by a large number of visitors, such as at open campuses in universities, eliminations of Manzai contests at actual theaters [b], and demonstration tests in hospitals [19]. We thus proved the effectiveness of the developed Manzai robot control system for the required specifications.

Moreover, as communications are performed between robots and external computers via wireless LAN, some problems may occur in actual environments, hindering a part of the Manzai performance or causing time delays. Although we have considered such a problem, the implementation of a more robust control system remains an issue to be addressed in the future.

Our efforts to develop the Manzai-script-generating techniques are focused on the generation of Manzai dialogues, leaving some room for us to review the Manzai performance in more detail. In actual Manzai performances, controlling the rise and fall of voices and the tones plays an important role in provoking a laugh. Other important considerations include time delays between dialogues and performance, for not just rotating on the spot but also for moving back and forth. Another issue to be addressed in the future is to create the Manzai robot more "fun" by improving the performance-script-generation system and by developing its performance system.

6. Conclusions

In this paper, we described the system developments required to automatically generate Manzai scripts from Internet articles with given keywords and integrate the control systems for Manzai robot duos. We used RT-Middleware to implement separate components for the common and specific parts and integrated the control systems so that various types of robots can use the components in the common part. In addition, we created the components according to the performance to be used for the Manzai scripts; this has made the system more flexible to any additional performances and improved its scalability. We also integrated the interfaces by implementing the user interfaces to operate the robots as common Web applications. Furthermore, we proved the effectiveness of the developed Manzai robot control system in terms of its flexibility and scalability by incorporating it into existing robots.

In the future, we plan to address issues including the development of a more robust Manzai robot system, and making the system more "fun" by improving the script-generation system for new performances and developing its performance system.

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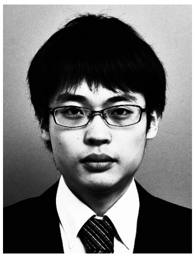

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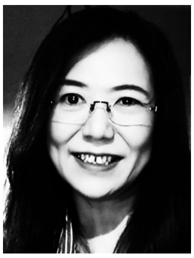

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