Development of Caricature Robots for Interaction with Older Adults

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Abstract. This paper proposes a concept of combining the techniques of classic animation and robotic design to create a simple robot capable of interacting with older adults, denominated *"caricature robots"*. A caricature robot can be described as "a non-humanoid robot that can show simplified humanoid motions in exaggerated ways". To achieve that illusion, three key elements should be met in a caricature robot: *functionality, simplicity in motion and personality*. While interaction for every older adult can be different, users are allowed to personalize their caricature robot by creating their own set of motions and personas that suits their personal taste. This is made possible through the "Body Cerebellar and Brain" control structure and the MotionClips software developed in this research. MusicMouth is used to exemplify caricature robots. Through the advantage of customization and personalization, caricature robots present a range of scenarios.

Keywords: Interaction · Caricature robots · Robotic motion design

1 Caricature Robots

From the appearance design, robots can be divided into humanoid robots and nonhumanoid robots. Humanoid robots are designed to imitate human-like appearance and movement. For example, Honda's Asimo in Fig. 1(a) contains basic setup of trunk, hips, upper and lower limbs and head. Its movement implementation intends to emulate human motions, including basic walking, grabbing things, arm movement and even dancing. Many non-humanoid companion robots are designed to resemble pets. For example, Paro, described by Guinness world records as the "world's most therapeutic robot of its kind" www.parorobots.com has a pet-like appearance. As shown in Fig. 1(b), it is designed as a seal covered in soft fur like a stuffed animal.

These robots are designed to have a personality, which is expressed by their robotic motion. Paro for example, shows soothing movements and eye blinking which denote a "cute" personality. Asimo, in contrast to Paro, presents more aggressive movements that show a jovial personality, a younger, almost childlike spirit. For robots like Paro, their "personality" or set of motions have been embedded in it, a set of reactions that are triggered by the users to simulate interaction. The limitation with this embedded

Fig. 1. (a). Asimo http://asimo.honda.com (b). Paro

personality is obvious when trying to distinguish one Paro from another, due they will all be the same and could not be adapted to the different needs or requirements to each individual person who would interact with it. Over the past few decades, robotics has been moving forward in aiding older adults in their daily tasks. Modern medicine as well has been using robotic assistance for several tasks in homecare and medical applications.

There are some important needs for older adults and dementia care that robotics can cover, as numbered below:

- Reminiscence therapy: Therapy based on recollecting past experiences or events through an audio-visual experiences [2, 3].
- Memory aid: Through audio-visual reminders and assets to keep the oriented while doing their daily tasks [2].
- Communication: Research has shown that demented patients have express they feel lonely [4, 5], although this problem is not exclusive for demented patients but also between the elderly population of the world.

The work presented in this paper describes a new approach using caricature robots for interaction with elderly people. A caricature robot as "a non-humanoid robot that can show simplified humanoid motions and emotions in exaggerated ways." A lab-based evaluation, in which 16 older adults aged 52 to 80 interacted with the facilitator through a caricature robot, showed positive results on acceptance of the caricature robot. The levels of anxiety of the older adults were low while interacting with a caricature robot based on their heart rate; also the level of concentration while interacting with caricature robot is high based on the record from an eye tracker. This evaluation was carried internally at the Gerontechnology Research Center during the process and development of the caricature robot concept, these results will be published in an upcoming paper. This paper presents the development of "caricature robots" and how they can become part in the daily lives of older adults.

2 Method, Materials and Concepts

This research intends in a simplistic way to present personalities in caricature robots that can be adapted to the different older adults who come across interacting with them. While interaction for every older adult can be different, users are allowed to personalize

their caricature robot by creating their own set of motions and personas that suits their personal taste. This is made possible through the "Body Cerebellar and Brain" control structure and the MotionClips software developed in this research. A set of "rules" or elements were defined for the creation of caricature robots, these elements we defined as the "key elements" that every caricature robot must contain to be denominated as caricature robots. These key elements are Functionality, Simplicity in motion and personality. To be able to explain these key elements we will use the Music Mouth project in this paper to aid us not only in the definition of our concept of caricature robots and their key elements, but the scenarios in which it can be used and how it can be included in the daily lives of older adults for interaction.

2.1 Three Key Elements for Defining a Caricature Robot

Caricature robots, while being non complicated robots; they achieve interaction and can become part of households due to their unique characteristics, that do not rely on the esthetics only but on their core function and motion design to be able to express emotions through simple mechanisms. These key elements combined in a caricature robot are:

Functionality. The first element of a caricature robot is its functionality, which is the crucial factor of determination on how to include a caricature robot into a household. This is what will determine where the robot will be placed, how it will be used and how it can aid in one way or another. The inherent functionality, for example, photo frame holders, trashcans, lamps and more, brings a full range of possibilities on how to include caricature robots to our daily lives at home.

Simplicity in Motion. In a caricature robot, the mechanisms added to the original functionality to facilitate robotic movements are expected to be simple but allow movements for expressive motions. In contrast with most humanoid robots that contain sophisticated mechanisms to achieve humanoid movements, a caricature robot intends to use a small amount of degrees of freedom to achieve expressive motions.

Personality. The personality of a caricature robot relies mainly on the design of motion. In particular, the movement exaggeration is a crucial part to show the personality of a caricature robot. The design of motion can be fully based on principles of cartoon character design used by animators and artists around the world. *"Disney Animation: The Illusion of Life"* [6], considered in the industry as the "Bible" of animation, describes the motion and animation principles for cartoon characters, that could be combined in a robotic body to achieve almost life-like expression in the non-humanoid robot. These principles are:

- Squash and stretch
- Anticipation
- Staging
- Straight ahead and pose to pose animation
- Follow through and overlapping action
- Slow-out and slow-in

- Arcs
- Secondary Action
- Timing
- Exaggeration
- Solid drawing
- Appeal

Through the design of motion, caricatures are able to give life to unanimated objects like lamps, carpets [7] and even a toaster [8]. Of all 12 principles above, the "solid drawing" principle is the only one that cannot be fully applied to a mechanical body yet can be used in the facial expression design.

2.2   Music Mouth for Illustrating the Characteristics of a Caricature Robot

"MusicMouth" shown in Fig. 2 is used as an example to illustrate the three characteristics of a caricature robot. MusicMouth's core functionality is to be a speaker, which is a common appliance in many homes. Simple elements of motion were added to this speaker, including an up-and-down motion that simulates the "mouth" and the side-to-side motion that turns the "body" around. These two degrees of freedom keep this robot simple but are enough to express personality. Personality was added through the motions and visual elements added to the robot. MusicMouth opens and closes its mouth when an audio input is detected. By taking an ordinary object as the speaker and converting it into a caricature robot, more scenarios are possible. This speaker now can use its personality and motions to be a more life-like speaker, an in-call avatar, or just and "interactive partner" which converts digital source into physical motion. This first step on developing this caricature robot was to find a basic common element in a home that wouldn't be invasive, that would be functional and that could be inserted in homes easily. The conversion of the ordinary speaker into a caricature robot was based on a simple design process of the addition of servo motors and controllers that would react to the input received and, along with the speaker generate an output that could give this "illusion of life" through the key element number 3 described before in this paper, Personality. We recently finished the real prototype Fig. 3 of MusicMouth in which we could test the different features that can help us create user scenarios in which such caricature robot can be used to interact with older adults.
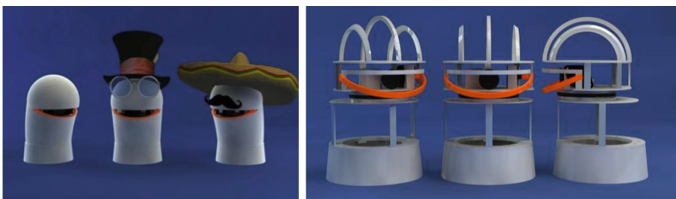
**Fig. 2.** Musicmouth with different visual aids to define personality
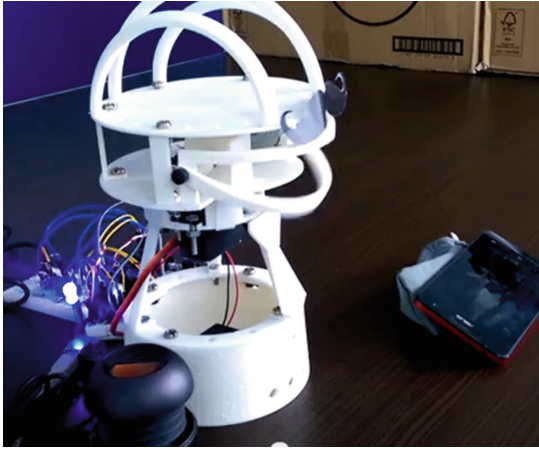
Fig. 3. Musicmouth first prototype

3   Software Development and Discussion

While interaction for every older adult can be different, users are allowed to personalize their caricature robot by creating their own set of motions and personas that suits their personal taste. This is made possible through the "Body Cerebellar and Brain" control structure and the MotionClips software developed in this research.

3.1   Developed Software – The "Body, Cerebella and Brain" Control Structure

MusicMouth is based on the "Body, cerebella and brain" control structure that keeps the whole set of commands and instructions on the software of the system yet not on the hardware. MusicMouth's input can be from music, a Motionclip file or any other audio input available into the application and a micro processing unit controls it, which is ready to receive and execute the different commands from the input application. This allows customization to happen inside the application for persona creation and intensity of interaction. This can also allow easy update on the system without the need of changing anything on the hardware. To facilitate this customization to the users, an application to go along with these caricature robots has been created called Motionclips, which allows the user to create audio and video files with a set of motion commands assigned by the end-user to fit his needs and ways of interaction (Fig. 4).
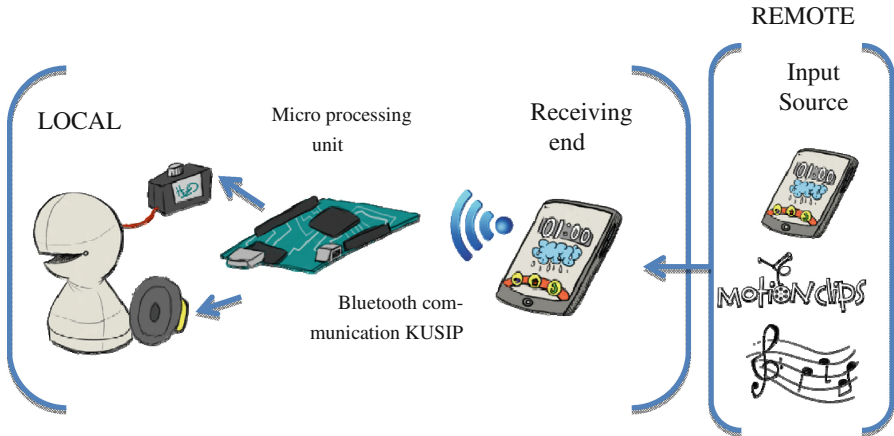
Fig. 4. Control structure of MusicMouth

MotionClips is an application that allows the end-user to create and send custom video and audio content with e-motions (electronic motions) through a caricature robot. This content is saved in a "video + motion" and "audio + motion" format that caricature robots recognizes. This format setting is simply a video or an audio file that carries along with it a command file that will trigger motions of the robotic body of the caricature robot to play along with the video and audio content. MotionClips can also be employed to share audio content with motions through MusicMouth. This simple case-scenario takes two users living afar. MotionClips allows the creation of custom animated motions to accompany an audio clip. When this audio + motion is shared to a caricature robot, the robot will reproduce those motions predetermined by the remote user during while the audio clip is being reproduced.

3.2   Music Mouth and Usage Scenarios for Older Adults

MusicMouth as a caricature robot can be used in many different scenarios based on the features that were added to this home speaker, now transformed into a robot. Music-Mouth was created and designed to give life to the sounds emitted by the speaker, bringing a new way to not only hear the intensity of the sound interaction but also add a visual value of such intensity. We will now discuss a couple of scenarios where MusicMouth is used for interactivity. Not only presenting himself as an interactive music speaker which as shown in the image converts the audio input received from a smart device through Bluetooth and converts it to motion and expression while also amplifying the sound signal. MusicMouth does the opposite of what current technology trends are doing; MusicMouth converts a digital input into an analog output. In the second scenario we hold two ends in this "visual equation" in which the caregiver can communicate with the older adult through MusicMouth. This scenario is being applied to older adults who by many different circumstances live in solitude and are not able to keep constant communication with their caregiver, family members, friends etc. Using

a caricature robot like MusicMouth as a gate of communication can aid to the loneliness feeling that many older adults that live by themselves struggle with [9]. Opening a gate of communication between older adult and caregiver, that has the added value of interaction through motion, MusicMouth is also a telepresence robot. Reduced to a very simplistic approach in which the monitor or screen used in telepresence robots are replaced by motions and emotions expressed through the caricature robot itself; MusicMouth becomes a real life avatar.

MusicMouth also presents the possibility of adapting itself into different circumstances and needs to the different potential users. MusicMouth can be used to remind them the different daily activities they have on their schedules. The personality and appearance of MusicMouth will not be the same one to another not only through the customization of input it receives but also through the different accessories MusicMouth can have to change its appearance without affecting the functionality. The user should be able to define the personalities and interaction of their caricature robots. MusicMouth can be an aid to elders living alone, not only being a gate of communication with their caregivers or family members but also being a personal reminder for their daily chores and important tasks as taking medication and more. These reminders and tasks can be programmed by the caregiver or family into their own smart device which is connected to MusicMouth, keeping a simple yet interactive way of communicating with their loved ones.

4   Conclusions

Caricature robots open up the possibility to engage older adults in an interactive way of communicating with their loved ones. Caricature robots are defined by three elements, functionality, simplicity in motion and personality, all of the above based on the main objective that the creators of caricature robots desired for this project, to have a useful robot that can be put in homes without being complicated to build or operate. Caricature robots are not intended to be complicated robots or robots with a humanoid behavior, they are simple robots that are capable of expression. The video + motion and audio + motion format created for caricature robots allow users to interact remotely with their loved ones. Customization and persona creation allows caricature robots to differentiate themselves from other available robots allowing the user to define how and where these caricature robots interact with them. The interaction with older adults through caricature robots goes beyond the local scenario. These robots intend to be an open gate of communication between families or caregivers with simple robots that are not invasive and can be included at homes. For our future works we are to implement MusicMouth and other Caricature Robots in home environments designed for elders suffering with dementia in Taiwan, opening a gate of communication between them and their families that usually are separated in great distances due work locations and more. Caricature robots are now in development but they represent a new option in robotic design for households where older adults live, by being daily use objects by themselves through their functionality element of design, we wouldn't present objects that are unfamiliar to them. We can take a picture frame, a speaker, a phone holder and more common objects and add these key elements of caricature robots as shown with

MusicMouth and turn them into robots with personalities. The "cute" factor of their design is a non-threatening one, which allows older adults to feel more relaxed around them as shown before in the lab-based experiment. Caricature robots not only intend to be a feasible and sensible option to include robots at home, but also intend to be the gate of communication and interactivity that is absent in many households where older adults reside alone. MusicMouth and other Caricature robots have been 3d printed, being this, a gate of possibilities for many to be able to obtain customize and print their own, cutting down the costs of production to a minimal, making it affordable and reachable even in places where technology is not an option due to lack of financial resources. Knowing that not every older adult gets acquainted easily with new technology, caricature robots allow a wide range of possibilities in customization, allowing the users and caregivers to adapt them to their own needs and taste. We believe that caricature robots are a good open door to finally allow robots into our daily lives without being intrusive or obsolete "toys" without functionality. Caricature robots do not intend to denigrate our older adult community by designing technology "specially for them", we believe that older adults are an active community that like to play with technology as well, and caricature robots is technology for everyone to use, that is simple yet we kept the "Fun" factor on them for everyone to enjoy. Caricature robots as mentioned before, are to be useful in homes, are to be non-threatening and reachable to anyone who would like to own one to have a home care system through a simple "robotic friend", caricature robots.

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