Zorabots: A suitable robot-mediated telerehabilitation interface

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Abstract. Research on NAO robot-mediated Autism Spectrum Disorder (ASD) therapy intervention via telerehabilitation network has been gaining popularity in recent years. It eliminates the distance barrier between a therapist and a child with autism by allowing remote physical interactions between them thus enabling the therapy to be conducted even in a long-distance. In general, the system requires a robot, a child with autism, and a helper which normally is a close kin to be present at one place and a specialized therapist at another. Connected via remote communication technology such as the Internet of Robotics Things (IoRT), a remote therapist is able to monitor the therapy session through robot vision or its sensors and if necessary, provide physical feedbacks through robotic features such as voice or body movements. One of the system’s important aspects is the therapist’s interface controlling the robot. The interface must be user-friendly to non-programmer user yet having enough technical features to control a sophisticated NAO robot. Choregraphe, an official NAO robot platform and interface to program and control the NAO robot, has many advanced programming functions. Thus, it is considered quite intimidating to the non-programmer user, in this case, a specialized therapist. As an alternative to this interface, this paper reviews the suitability of commercially available software, Zorabots, as the therapist’s interface to monitor and control NAO Robot in telerehabilitation environments.

1. Introduction

The Autism Spectrum Disorder (ASD) prevalence leads to the growing research related to robot-mediated therapy intervention via telerehabilitation network, as a technology-based solution for ASD therapy. Due to its programmability and other sophisticated features, the research utilizes NAO robot which has been gaining popularity in recent years [1], [2], as the telerehabilitation medium. This latest
solution aims to eliminate the distance barrier in order to serve as one of the practical solutions in autism therapy. Meanwhile, the Internet of Robotic Things (IoRT) has been identified as a suitable tool to connect multiple robotic devices in a physical telerehabilitation system [3]. It provides machine-to-machine (M2M) communication and intelligent data processing in telerehabilitation environments. During a telerehabilitation therapy session, this tool together with robotic features such as vision recognition and touch sensor are able to provide insights to the therapist’s device based on the autistic child’s movement, even though they are far apart. Vice versa, the therapist can provide their remote feedback through a robotic arm and instruction via voice afterwards [4, 5].

In general, the system requires a robot, a child with autism, and a helper which normally is the patient’s family member (i.e. parents) together in one place, and a specialized therapist at another end (Figure 1)[6]. Connected via a remote communication technology such as the IoRT, the remote therapist is able to monitor the therapy session and if necessary, provide physical feedbacks through a robot. The monitoring and providing feedback processes can be facilitated through appropriate interfaces such as the Choregraphe software; an official NAO robot platform and interface. Besides monitoring and controlling NAO robot, Choregraphe allows a user to create behaviours and then test them in simulation as well as on the real robot. Plus, an advanced user can also enrich the behaviours using their own programming code. However, the software can be quite intimidating to non-programmer user (i.e. a specialized therapist). The selected interface for the telerehabilitation system must be user-friendly to a non-programmer yet equipped with enough technical features to monitor and control a sophisticated NAO robot. As an alternative to this interface, this paper reviews the suitability of a commercially available software, the Zorabots as the therapist interface to monitor and control NAO Robots in telerehabilitation environment.

![Figure 1. Robot-mediated telerehabilitation architecture](image)

### 2. Literature review

#### 2.1. Robot-mediated intervention via telerehabilitation networks

The rapid progress in robotic technologies has lead to the growing research on robot-mediated innovation for ASD educational intervention. In general, robots used in autism intervention can be differentiated based on their physical appearances. The most common robot types used in autism research are non-humanooid, animal-like, and humanoid [7]. Based on human-robot interaction (HRI) study, humanoid robots such as the NAO robot have been proved to be an effective therapy medium. Its less complex features compared to human and its ability to facilitate elicitation in ASD therapy can be important tools during a therapy session [8].

However, despite showing great promise, several challenges, including cost, safety, and efficacy must be addressed by autism-related robot-mediated interventions’ researchers to increase its accessibility and reliability [9]. For instance, the cost of these prototype robots such as NAO, Keepon,
and KASPAR remains high even though they have already gone through the mass production level. Consequently, although the number of people affected by autism keeps increasing, this kind of treatment is currently only limited to few therapy centres and hospitals, making it difficult to serve as practical solutions to most of the population. Moreover, in order to achieve a wide coverage, researchers also need to improve its safety and efficacy in less-supervised settings. The current heavily supervised setting in most robot-mediated interventions is not going to last since qualified autism therapists or related technical engineers are greatly outnumbered by the population. Coupled with the fact that children with autism are often subjected to limited participation in age-appropriate activities at home, school, and community, much attention has been given to telerehabilitation as a plausible effort to overcome the barriers of distance, time, and cost in providing rehabilitation services through robot.

2.2. Nao Robot Control Interfaces

NAO is a commercially available advanced humanoid robot developed by Softbank Robotics. Users can program and control the NAO robot through a programming framework called NAOqi [10]. The possible programming languages for development in this framework are Python, C++, and Java. In order to do the programming, the user must first install the necessary Software Development Kit (SDK) which is downloadable from the official Softbank Robotics website. This text-based programming method is suitable for advanced programmers as it is the primary and the most effective method to control the robot (Figure 2). It provides the full capabilities to utilize all NAO robot basic to the most advanced features. As for users with less programming capabilities, they usually prefer more user-friendly interfaces to control the NAO robot. Depending on application, the interfaces such as Choregraphe, ASK NAO, and unofficial android controllers can be more than adequate to control the robot.

```
import time
import naoqi

module = "pythonModule"

# Create a new module
newModule = "python class myModule test auto documentation"

def pictureChanged(self, strVarName, value, strMessage):
```

Figure 2. Programming language (Python) to control NAO Robot

2.2.1 Choregraphe. A Choregraphe platform provides an animated interface to control a NAO Robot [11]. As shown in Figure 3, it allows a user to create behaviours by dragging and combining several function blocks. The behaviour can then, be tested in simulation, or directly on the real one. Each of these blocks represents a group of pre-determined text-based programming scripts. Through the combination of blocks, the user can monitor and control the robot. Users with enough programming
skills can also enrich the behaviours with their own programming (Python) code. Depending on the user’s skills, most of the NAO robot features can be utilized using this platform.

![Choregraphe interface](image)

**Figure 3.** Choregraphe interface

2.2.2 *ASK NAO*. An animated ASK NAO interface was specially developed to allow a teacher to conduct in-class NAO robot modules to teach autistic children [12]. The modules, which were divided into task and reward categories, were pre-developed for teachers to utilize. Based on Figure 4, the interface consists of 4 main tabs; Child tab, Playlist Tab, Play Tab, and Create Tab. The Child tab contains the child’s profile, progress, and history. This is where the teacher and parents can monitor the progress of the child. The Playlist tab consists of editable sequence of modules made up of combinations of tasks and rewards. Then, the Play Tab is used to upload and play the playlist for the education session. Lastly, the Create tab allows teachers to create their own quizzes and embedding them into one of the pre-developed modules called Quiz me. However, it seems that Softbank Robotics no longer support this interface as its webpage is currently inactive.

![ASK NAO interface](image)

**Figure 4.** ASK NAO interface [12]
3. Methodology
The method of reviewing the Zorabots interface is via engaging with the Zorabots (NAO robot with Zora Control) itself. All standard user account accessible functions will be run on an actual NAO robot and the comment will be made from the view of robot-mediated telerehabilitation's therapists. Through the actual engagement, each Zorabots interface functionality will be reviewed based on therapy scenario examples which are normally found in autism robot-mediated telerehabilitation therapy [1]. The scenarios and actions to be considered by the therapists are described in Table 1.

Table 1. Therapy scenario examples and the therapist’s respective action

| Therapy scenario examples (not limited to) | The action needs to be taken by therapist (through robot as a therapy medium) |
|------------------------------------------|--------------------------------------------------------------------------------|
| 1) The child imitates the movement of robot | To visually monitor the child during therapy |
| 2) The child answers a question | To hear and give voice feedback |
| 3) The child requires a robot guidance to show therapy steps | To provide physical instruction through robot movement |
| 4) The child needs to dance with the robot | To dance with the music |
| 5) The therapy module requires a robot to move around | To walk around |
| 6) The robot needs to show angry or happy face to the child | To express emotion |
| 7) The child looks at the robot | To make eye contact |
| 8) The robot is required to point to the object to the surrounding object | To point finger |
| 9) The robot needs to start predefined therapy routines | To specifically select the predefined robot module or therapy routines |
| 10) The child has completed the current therapy routines and needs a new one | To develop a new therapy routine and playlist |

4. Results and Discussion

4.1 General review on Zorabots Interface
As shown in Figure 5, the Zorabots interface can be accessed via filling up its IP address in Google Chrome’s address bar. Connected through the internet connection (Wi-Fi), the IP address will be spoken by NAO robot once its chest button is pressed. The interface has 4 main tabs; Zora, Behaviors, Steering, and Composer. In addition, on the top right side, there is a control bar which controls the robot’s voice volume, speech speed, battery status, and the general setting.

The Zorabots interface begins with the “Zora” tab; a simple welcoming page (Figure 5). While the “Behaviors” tab shown in Figure 6 summarizes the predefined robot basic behaviours (postures) and more complex behaviours (modules) available on the robot. The reviewing, playing, and editing processes of the robot behaviours can be done here. Next, the “Steering” tab allows the user to control and monitor the robot. As shown in Figure 7, multiple different menus (Behaviors, Movement panel, Basic functions, Camera and microphone options, Variables, Text snippets, Compositions, Head movement, Point at something, and Eye colouring) are accessible for the user to utilize. The last tab is
the “Composer” tab (Figure 8). It comprises of “simple” and “advanced” modes. This tab allows the user to manually set the routine (consisting of multiple available behaviours) for the robot by dragging the behaviors blocks into the timeline.

Figure 5. Zora tab

Figure 6. Behaviors tab
4.2 Zorabots interface functionality review based on therapy scenario examples

Scenario 1 requires the therapist to have a clear visual content of the child during a robot-mediated telerehabilitation therapy session. Through NAO robot vision, the Zorabots interface provides this content through the Steering tab’s camera option. Besides, the therapist is also able to take pictures and record necessary videos. The therapist is able to hear a child’s response by clicking the microphone option (below the camera option). Similar to the camera option, the therapist can record audio contents. Moving on to Scenario 2, there are two options to provide voice feedbacks to the child using the robot’s voice. The options are non-animated and contextual animated methods. Simple non-animated method works when the user enters a text in the speech module editor inside the text balloons above the image of a robot. The contextual animated speech option can be realized in three ways; speech module (Steering tab), predefined text snippet (Steering tab), and speech composer block (Composer tab).

Next, all actions needed to be taken in Scenario 3, 4, and 5 require the therapist inputs via the Zorabots interface to control the robot’s movement remotely. For instance, the therapist can guide the
child to follow the robot’s movement step by step by playing the behaviours including postures and modules in either Behavior or Steering tab. The behaviour’s module section can also facilitate Scenario 4 as it also contains some music and dance modules to entertain the child. If necessary, the modules can also be edited to suit the therapy protocol. Meanwhile, the movement panel allows the therapist to walk the robot around seamlessly. This conventional remote control-like function is so efficient yet simple enough to move the robot around in Scenario 5.

One of the advantages of using robot as a telerehabilitation therapy medium is its less intimidating physical features compared to humans. However, the robot still needs to be able to express emotions (Scenario 6) and make eye contact (Scenario 7). In addition to the robotic postures, emotions such as anger, happiness, or sadness can be represented via the change of the colour of the robot’s eyes. The Nao robot’s eye colour can be controlled using the Steering tab’s eye colouring. Whereas, the robot’s eye contact direction can be controlled using the Steering tab’s head movement. The eye contact will be more natural if the “blink eyes” and the “follow person” options in the Steering tab’s basic functions are activated. Similar to the location of eye colouring and head movement control is the “point at something” control panel. This panel allows therapist to facilitate Scenario 8.

Finally, Scenarios 9 and 10 involve playing and developing a series of routines in a therapy session. Using the simple composer (or advanced composer) in the Composer’s tab, the therapist has endless possibilities of the routine options at disposal. Combining block doesn’t require any programming skill, but it requires some familiarization with the function of each block.

4.3 The limited coverage issue
As discussed in the previous sub-chapter, at least at the interface level, it seems that the Zorabots interface will be one of the most suitable for therapist use in robot-mediated telerehabilitation environment. Its functions are well suited with the therapy scenario examples and the therapist’s respective action. Moreover, the interface does not involve high-level text-based programming which made it suitable for non-programmer users, in this case, a therapist. However, the coverage of robot control is limited to only Wi-Fi coverage. This means that the robot and the therapist interface must be connected to the same local area network to allow the system to work. Thus, without the engagement with remote communication enabling technology such as the IoRT, the system only can work within a local area network coverage and is incapable to effectively eliminate the distance barrier between therapist and the autistic communities through robot-mediated intervention.

5. Conclusion
Based on the results and discussion, it can be concluded that the Zorabots interface functions are well suited with the therapist requirement in a robot-mediated telerehabilitation intervention setup. However, network architecture development needs to be improved to increase its robot control coverage. The development can embed a remote communication enabling technology such as the IoRT for this to be realized.

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