*Ball Buddy*

*Companion Robot to Support Elderlies*

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***Abstract*—This electronic document is a description of the robot to support those aging-in-place by being a supportive companion. Ball Buddy is an aging-in-place companion robot that would help the elderly achieve enliven daily life. This document itself covers research that proves the need of Ball Buddy, current solution, a system description, and future work of Ball Buddy. This task involved many processes from West Virginia University (USA) by putting together an interdisciplinary group including Electrical Engineering, Computer Science, and Computer Engineering major students. Ball Buddy is developed newly from Spring Semester 2019 without using any resources from previous groups by creating new and efficient outer design that allows easy fix and potential upgrades. In addition, we created system instructions for future groups to enhance the basic Ball Buddy with their own ideas and designs. We believe this project can have a great, positive impact to elderlies who are suffering from loneliness and isolation, which is major issue of today’s society. Ball Buddy, however, will become their friend and entertain elderlies with its functions.**

***Keywords—Aging-in-Place, companion robot, entertainment, potential upgrades, real-life size, reduces loneliness and isolations***

# Introduction

In United States, 78.0 million people are estimated as elderly populations over 65 years and older [1]. According to the 2016 Population Estimates, 15.61 % of populations were recorded as elderlies and scholars indicated this number will increase every year [1]. In 2008, Tokyo announced that there were more than 2,200 reported lonely deaths who were 50s and over 65 years old [2]. Studies show the reasons for the increased deaths of elderlies includes social apathy and life stress [3]. Another study by Louis Jacob, Josep Maria Haro, and Ai Koyanagi shows that loneliness explained 84 percent of those living alone suffer common mental depressions [4]. Elderlies’ lonely death from being isolated from their families and society is clearly a major current issue.

*Ball Buddy* is our attempt to provide a solution to the problem. With its real-life size and entertaining features controlled by users, *Ball Buddy* comforts and reduce loneliness of users. Recent technologies offer entertainment robot that can be controlled by app. Ball Buddy got motivation from this idea but with easier user interface designed for elderlies, and a real-sized that elderlies can rely on as companion more than a toy. In this paper, we will provide brief scenarios where this robot will be utilized and describe the overall architecture of the *Ball Buddy* design and some of its applications.

# Background and Related research

# Background

Over the years, there have been many advanced technologies to entertain individuals. As of the third quarter of 2019, Android app store offered 2.47 million apps while Apple’s App Store offered 1.8 million available apps for iOS [5]. Robots on the other hand, amounted to 1.7 million units were in market in 2015 [6].

Our group have noticed that many of the applications were not easy to use with having complex interface and gaming rules and controls. Also, we observed robots that were on the market for entertainment were mainly aimed toward children or have a small physical interface for use. The technological complexities and limitations that these robots provide does not provide perfect solution for the elderlies. A recent study in 2019 reveals smartphone app usage patterns of older adults use fewer apps, keep their phones open longer, and mainly in early day for fewer times [7].

With this observation, our group decided to design a robot with easy and simple interface with visible size of buttons and a robot that is real life size to let users feel like they are not just controlling a toy but feel like they are with a friend.

# Related Research

#### Arduino Software

Programming software from Arduino came to consideration for programming *Ball Buddy*. Arduino software was chosen over other programming tools such as ROS or C/C++, letting developers to have easier access to the Arduino circuit that was used with many resources. The advantage of using this program was its simple characteristic to debug the code. The code allows access to developers and future developers to identify which component is connected to which port on the circuit allowing developers to easily check with the code or the circuit to resolve problems or modify the code.

#### Third Party Application Development

There were several considerations for developing the application for Ball Buddy. The application of a third party LED controller from Maker Pro was used to test the Bluetooth module. After checking the module, rather than developing an application using tools with Python or JavaScript, the team modified the source code with the initial Bluetooth testing app. This allowed a simple user interface that the team aimed for.

#### Third Party Videos

For designing the internal body and the exterior of the robot, the team researched many videos on YouTube before using the outer parts from the previous group. Many videos were watched as references. The problem with these videos was the cost and ineffectiveness. The solution for this limitation was suggested. The final outer pieces that were designed allowed both a stable and easily repairable robot. The inner design also allowed accessibility for any modifications.

1. West Virginia University 3D Printing

The major option to print out the outer designed pieces was to work with the WVU 3d printing lab. 3d printing was key of the design that reduced a lot of costs compared to using the shell from previous group as well as allowing easy fix of internal hardware without opening the whole sphere for adjustments. The solution to this was to print out pieces from the WVU 3d printing lab. However, the problem with this was the time required to print the pieces and the limited available printing sources. The process was very lengthy, therefore, for future groups it is strongly suggested to use the pieces that are already made from our group. Future groups are recommended to either find a method of fabricating more pure and stable pieces or to print several replacement panels in case of a break.

# Scenario

Let’s consider the following scenario: James, an 80-year old retiree lives alone in his house without his family. His wife passed away ten years ago, and his children barely visit him. He misses playing with his son and grandchildren when they were young but his grandchildren, now in their 30s, would not visit him anymore. James is isolated from his family but prefers to stay inside his home because it is hard to drive outside. There are also not many places to spend his time outside of his home due to mobility limitations. In addition to his isolation, he is feeling apathy and bored every day. The only noise from James’ home is from television. James’ family considered moving him into a retirement community, however, the price for such place was too expensive, especially for James who does not have much income. James’ grandson recommended James to have a puppy as his pet. James, however, is not confident to feed the puppy every day, take him outside, and give enough care to the new pet. The goal of the Ball Buddy project is to support people like James who feel loneliness and apathy. Ball Buddy will be his best companion who only needs charging but provides entertainment and liveliness day-by-day.

# System Description

Ball Buddy is managed by students of Lane Department of Computer Science and Engineering of West Virginia University (WVU). The developers of this robot can add, edit, or delete the content by easily modifying the source code using the Arduino software. The developers can also add, upgrade, or make changes to the hardware of the robot by easily modifying the internals of the robot by removing the 2 side panels of the robot’s outer shell. The simulation features a series of predefined functions that demonstrate our project and how the Ball Buddy would react.

## Simulation

The simulation on the simulation application shown in Fig. 1 is run by the user on an Android smart device. The user can simply hit connect with Ball Buddy after downloading the application and connecting via Bluetooth. The visuals are mainly consisting of large buttons in order to simplify the interface for users with visual problems or trouble with hand movement. The simulation is designed to have a main loop which implements the commands from the user and wait for the next command until the user disconnects the robot and the application following Fig. 2. From this design, the system can easily pull the command data from the user and perform the functions without long delay or unexpected disconnections.

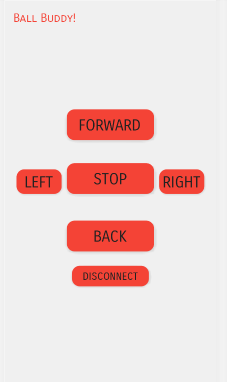


Fig.1. User Interface

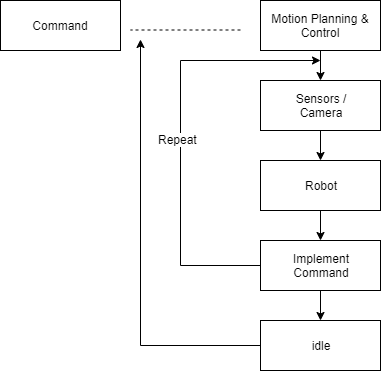


Fig. 2 System Architecture

## Adding or Editing functions

## The group can easily access the source code by using Arduino software. Using this software, the group created a code in which moving functions, dance functions, and bluetooth connections are integrated. The group can use this source code to enhance the movement of the robot by consistent testing to obtain satisfying movement. The group can also add or modify the dance function to obtain satisfying dance performances.

## Other users can obtain the source code to edit certain functions and be given permissions to edit the content by easily accessing the group’s documentation.

## Adding or Editing Hardware

## The side panels of the body are removable. Removing the side panels allows access to the basic hardware but more severe modifications would require pieces of the shell to be temporarily dismantled. The side panels also allows users to charge the batteries.

## After removing the side panels, one can identify the marked removable pieces through inside. Simply detaching two pieces creates enough space for group to modify the hardware inside the robot. Groups can easily troubleshoot when it comes to error with the hardware by removing the panels and testing out the inner circuits.

# Future Works

## Limitations of the Current Solutions

## The current design of Ball Buddy allows efficient accessibility to the hardware for the body parts. However, the outer design for the head piece is recommended to have new design. The current solution was to use the head part from the previous group, however, it was too heavy for the robot to hold it with the magnets on hand.

## Thus, it is strongly suggested to modify the head part by using lighter materials for the outer design, stronger magnets, and lighter parts inside of the head for an overall enhancement of the robot.

## Work with Fall Detection Team

The primary design plan of the current robot was to enable IR sensors to detect walls, stairs, and other obstacles to prevent Ball Buddy from colliding with objects or falling down stairs. The current solution was modified to utilize the camera from the head to allow users to explore and identify objects while driving the robot by checking the screen on their device. This allows users to control the robot to check the room without them physically going to check. However, the robot will be strongly enhanced if future groups can work with the fall detection team and utilize the fall detection software. Detecting users falling with the camera on its head will allow it to send messages or emails to the user’s family or other contacts in an emergency and be more supportive for elderly users.

## Update functions

For future work, it is suggested to update the current functions of the robot from using the app. Moving functions can be updated to achieve more smooth motions by modifying the current codes. It is also recommended to add a speaker and add more sounds to the robot to maximize the user friendliness. Not only sounds for Bluetooth but sounds for error notifications or battery warning sounds will also be helpful for the user.

## Create an application for iOS

## The application needs to provide service for iOS. In 2017, 728 million people were reported to use Apple iPhone devices [8]. The current application is limited for Android users. This limitation can be easily fixed by creating an application for iOS devices as well.

## Security

## The current application does not have a login system. For security, adding a login system would help to resolve the possible security problems. Enabling each account to add phone numbers of their family or close neighbors. When fall detection sensing ability is fully implemented in the future, the application can send emails or text messages to the contacts of the user to notify them of the emergency situation.

## The database would be needed to store each user’s information and it needs to be secured so that none of the information could be stolen. Security needs to be enhanced along with the fall detection function in order to store user’s emergency contacts that will notify others.

## Develop Artificial Intelligence

## In order to maximize the comfort to users, development of Artificial Intelligence (AI) would greatly improve the current personalization system. Associating with AI will enable Ball Buddy to learn many behaviors of users and show more connections to users. It will maximize its ability of being a companion to the users.

## Institution of Robotics, a startup founded in Israel in 2016, launched a robot which uses machine learning and computer vision to enable proactive suggestions, entertainment and activities in addition to wellness and environmental monitoring [9]. Developing AI for Ball Buddy would also allow the functions described above to become a real companion who can help emotionally and perform its tasks more effectively to elderlies.

## Update and Enhance the Simulation

## The simulation should be updated to demonstrate the Ball Buddy’s capabilities in a real household environment. Simulating in lab and on the road gave different performances on the robot’s moving functions. Therefore, Ball Buddy should be demonstrated inside a house to maximize the moving capabilities on different surfaces such as carpet or hardwood.

## Group Blogs and Documentation

## A group blog can be publicly accessed to view the project progress and document new changes to the systems. The group used WVU’s eCampus tools to write group blogs. Other documentation styles can help future groups to consistently develop Ball Buddy by having access to previous groups’ blogs and standardized documentations to interact with other groups.

# Conclusions

The current Ball Buddy can demonstrate moving functions, dancing functions, and provides a camera screen for users. The development was started from scratch and unique outer pieces for the ball design was accomplished.

This paper discussed the features and limitations of the current iteration of the Ball Buddy application and its hardware. There are several solutions in consideration to improve the current Ball Buddy for future groups. Numerous changes can be applied to the robot thanks to its replaceable panels and simple Arduino coding. The potential changes that can benefit the users have been outlined which is also beneficial to Ball Buddy to achieve our goal to present a great companion to elderlies.

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##### References

1. “Population Estimates -census.gov.” [Online]. Available: https://www.census.gov/content/census/en/search-results.html?stateGeo=none&q=aging population&searchtype=web. [Accessed: 11-Dec-2019].
2. Mihaela Robila (19 June 2013). [*Handbook of Family Policies Across the Globe*](https://books.google.com/books?id=1cM_AAAAQBAJ&pg=PA327). Springer Science & Business. p. 327. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [978-1-4614-6771-7](https://en.wikipedia.org/wiki/Special:BookSources/978-1-4614-6771-7). Retrieved 22 June 2014.I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
3. Zee News. (2019). *Noida sisters` case: It`s `kodokushi` in Japan!*. [online] Available at: https://zeenews.india.com/news/nation/noida-sisters-case-its-kodokushi-in-japan\_703409.html [Accessed 11 Dec. 2019].R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
4. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa (August 1987), “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
5. Statista. (2019). *App stores: number of apps in leading app stores 2019 | Statista*. [online] Available at: https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ [Accessed 11 Dec. 2019].

[6] IFR International Federation of Robotics. (2019). *31 million robots helping in households worldwide by 2019*. [online] Available at: https://ifr.org/ifr-press-releases/news/31-million-robots-helping-in-households-worldwide-by-2019 [Accessed 11 Dec. 2019].

[7] M. L. Gordon, L. Gatys, C. Guestrin, J. P. Bigham, A. Trister, and K. Patel, “App Usage Predicts Cognitive Ability in Older Adults,” *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI 19*, 2019.

[8] Statista. (2019). *iPhones in use worldwide | Statista*. [online] Available at: https://www.statista.com/statistics/755625/iphones-in-use-in-us-china-and-rest-of-the-world/ [Accessed 11 Dec. 2019].

[9] Bharadwaj, R. (2019). *Applications of Artificial Intelligence in Elderly Care Robotics | Emerj*. [online] Emerj. Available at: https://emerj.com/ai-sector-overviews/applications-of-ai-in-elderly-care-robotics/ [Accessed 11 Dec. 2019].