Games and Assistive Technologies for Rehabilitation
GATOR Next Year Group Recommendations

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Part 1 – New Motion Tracking Device/s

Currently the augmented reality rehabilitation games are in patient testing. The results based on patient feedback are positive. However based on the issues experienced throughout the year by our team as well as the occupational therapists, we would highly recommend changing the type of motion tracking device to the Kinect 2 or the Nimble controller.

The Leap controller was successful because it was able to meet our requirements; however, we were using it in a manner not recommended by the developer. The Leap controller is meant to be used while sitting on top of a desk or on a head mounted device. By directly inverting the controller the hand tracking quality dramatically decreases. When using the Leap inverted with a stand, we found that the following environment works best:

- 8 to 9 inches above the playing area
- Angled directly down
- Matte, textured material to act as the playing area (increase visibility for IR camera)
- Within the game code, leap HMD (head mounted display) optimizations should be enabled
- Low lighting/reduced IR lighting conditions
- Limited relocation of Leap after setup
- Verification of setup with Leap Visualizer

Meeting all of the environmental specifications is a hassle. Games become difficult if not impossible to play if one or more conditions are not met. Because of this, it was not feasible to conduct testing in patients’ homes.

In order to combat the problem of system reliability it is our recommendation that the continuing group uses the Nimble controller and/or the Microsoft Kinect 2. Integration of new device(s) with existing code could be fairly simple (See figures 1 and 2).

Nimble is mounted on the desk and it focuses on the perpendicular plane which would allow for much better tracking of patients hands and it would be much easier to deploy at home. As well as this based on current literature and media from Intuigine it appears that Nimble
features superior tracking compared to Leap. The one potential problem is whether or not nimble can track a hand that is rested on the plane the nimble sit atop.

Kinect 2 could potentially support a wider range of rehabilitation motions (head, arms, legs), but might sacrifice focus on finger and hand movements. Kinect 2 appears to have a windows SDK and also features support for JavaScript. This year’s group has not worked with similar hardware so we are unable to comment on the difficulty of integration, however it is our belief that successful integration could lead to major benefits in terms of types of rehabilitation offered to patients, and it could provide an easy to setup system for testing at patients’ homes.

Our main goals were to provide reliable motion tracking, a simple setup, and an efficient informational backend for therapists that can be used and accessed in a number of different environments.

```javascript
<script type="text/javascript" src="../../static/js/leap-0.6.3.js"></script>

var controller = new Leap.Controller({optimizeHMD: inverted});

p = controller.frame().hands[0];
if ( p ) {
    // Update image location
    x = p.palmPosition[0];
    y = p.palmPosition[2];
}
```

**Figure 1** Following code outline Leap instantiation in CreateJS game

```javascript
PlayState.init = function() {
    this.control = Kiwi.Plugins.LEAPController.createController(this.game, inverted);
}
```

**Figure 2** Following code outlines Leap instantiation in KiwiJS game

**Part 2 – Game & System Modifications**

Most of the games added were modeled off of popular mobile games to provide engaging game play while remaining simple as the primary audiences for these games appear to be elderly. The new games seemed to be more engaging for the patients because the patients were focused on beating the game and or doing better whereas when they played the older games they didn’t seem to feel challenged/enthused.

Some new games that the occupational therapists asked for that we didn’t have the time to get to are a flying game that is controlled by tilting the hand left and right. The game could feature a plan that has to move through obstacles and eventually based on difficulty the plane could have to go up and down and potentially left and right. Another beneficial game could be a racing game similar to the flying game.
The following list outlines recommendations for the existing game modifications and minor but necessary modifications to the back end:

**Fruit Viking**
- Vary trajectory and starting point of fruit more
- Add game progression (power ups, levels…)

**Maze** (also called Trace)
- Maze was one of the most problematic games that we dealt with as it was one of the games we inherited and it was created with CreateJS library. Maze can implement many different types of maze patterns and therefore many different movement patterns can be used. Because of the potential value of this game we recommend that the new group remakes this game using a more efficient library like Kiwi.
- Better paths for variety of movement and difficulty
- Music/sprite changeups

**Meteors** (also called Barriers)
- Meteors engagement could increase if some sort of progressions was added to the game.
- Missile shooting should correspond to finger gestures rather than closed fist. Typically the Leap was recognizing the hand as closed most of the time.
- Movement toward the edges isn’t great (CreateJS problem) and could be improved based on sensitivity or conditional corresponding to location ie.. if greater or less than boundary increase sensitivity.
- Ship spin doesn’t always occur and it probably should, however based on difficulty spin time should be decreased or increased.

**Water drops**
- Can be resource intensive since there are many animations, as a result sometimes not everything loads correctly (major two are the Leap controller script and the timer) typically a refresh fixes this game.
- Add potential mini game (If patient is doing well they could catch an egg, hatch a bird and then the bird could fly around on screen and catch as many drops as possible for a few seconds)

**Alien Invaders**
- Scalable difficulty settings
- Add progression in the form of different levels with enemies that have more challenging attack patterns (currently attack is only a falling missile)
- Penalty for missile fire in timed mode
- Sound effects
Whack-a-Mole

- The tracking is fairly poor however all the XY CreateJS games have poor tracking. To combat this, a rewrite could be done or it may be solved if nimble or kinect is used.
- This game has no progression, a change in mole type, hammer, environment, etc. could be beneficial.
- The music gets very repetitive
- Potentially require an action to smack a mole (currently a touch is a smack)

Break Out

- Resource intensive when many balls are on screen.
- Add spin/user control into paddle
- Progression is available in the form of two more levels however they are inaccessible since the game takes so long. Add a power up so that the levels can be beaten in 2 minutes plus or minus half a minute. (power up could be a fireball/laser which destroys balls without bouncing until it hits an edge)

Dolphin

- Add in type of progression or visual stimulation.
  - Sea weed / coral, other fish, one patient requested to see some sort of finish to the game

Pong

- Controls need adjustment

Leap Frog

- Progression could be effective.
  - Patient also requested to see a potential end to this game, frog princess was her specific suggestion 😊, but that takes away the mystery…
- Add more power ups (only spring, could add rocket like doodle jump, mosquito that flies you up. Etc…)
- Frog fall and jump speed should correspond to difficulty. (currently gravity is static and is the same for all difficulty)

Gestures

- Create a more visible hand model. The current model is hard for some patients to distinguish
- Better feedback system. Currently checkmark and X.
- Add on screen time/score/achievement
- Music that doesn’t suck
- Note: game uses playcanvas game engine, integration into system requires special environment and methods. See Readme in Repo.
Notes About Patients

- Everything from vision to focus to muscular movement can be affected by stroke. This can cause patients to require unique accommodations such as:
  - No Music
  - Varying speed/difficulty/tolerance
  - Omission of games from therapy
- The “default” position for a patient’s hand is sometimes a closed fist, a claw.
- Mental fatigue is just as common as physical fatigue. Too many environmental inputs (music, many images) and frustration can quickly cause mental fatigue.
- We want patients to get tired, but still happy.

Other Game Notes

- All the games could benefit from some sort of mini games, progression, or type of visual/audio stimulation as noted above.
- The max velocity reported needs to be addressed. Current calculation may be wrong or misleading in certain games. Note that Leap returns 3D vector of velocity.
- Automatic graphs of max velocity, average velocity, distance, etc…. could be beneficial. Current gameplay data can be downloaded in spreadsheet currently.
- Subscribing to Python Anywhere would allow for more CPU time and storage.
- Upgrading the website to employ HTML 5 features is recommended.
- Therapists expect a specific amount of play time for therapy, more or less could mess with results. Have a timed setting when adding new games.

As a final note, another goal would be to have automatic difficulty progression. When a user becomes good at a game, it becomes more difficulty. Acceptance of another browser other than Chrome would be nice too.

Part 3 – Emotiv Smart Home Automation

The team this year received the Emotiv headset with less than a month remaining before E-Days with the goal to build a smart home model controlled by thought. We succeeded in building a basic model with a light and fan that might be used with a person with spinal cord injury or similar, limb-limiting condition. All resources/hardware for that setup are on the designated computer in Sudeep’s Lab in the basement. If a better smart home model is desired, it is our recommendation that the new groups use signal processing techniques to generate more customized and precise commands, possibly for a larger number of devices.

The Emotiv headset, however, could have major applicability in other areas such as communication, controlling specific device (car, robotic arm…), or human emotion quantifier (usage in anti-espionage, marketing, user surveys..). Note that some research has been done with Emotiv in certain areas and it is recommended to research current common applications.
Next year’s team should ensure the protection and security of user data. User brain activity should not be available to outside entities in a similar way to any other medical information.

Another application along the medical route might be interpreting the user brain activity in order to make sense of user condition, health, etc… and make it available to the patient's primary physician or occupational therapist if the user consents to it.