ACCESSORIZED THERAPEUTIC
GAME EXPERIENCES FOR
TOUCH-ENABLED DEVICES

Alex Restrepo
INTRODUCTION
When helping in the rehabilitation of stroke and head trauma patients, therapists often find a need to measure the patient's control of the muscles in their torso.
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This is called **trunk control**.
Traditionally, therapists use one of two methods to measure trunk control:
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• Qualitative Analysis
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• Large, expensive medical equipment
In early 2010, GVSU’s School of Engineering developed a low-cost sensor device: the Quantitative Trunk Control Measurement Device (QTCMD), whose goal was the evaluation of trunk control in stroke or head trauma patients.
STROKE
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A Cerebral Vascular Accident (CVA) or simply “stroke” is defined by the World Health Organization as “a neurological deficit of cerebrovascular cause that persists beyond 24 hours or is interrupted by death within 24 hours.”
STROKE THERAPY

This disability ranges from mild to extreme
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- Stroke rehabilitation programs are strongly personalized and not generic: they are adapted to a particular patient, to regain as much function as possible.
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• Stroke rehabilitation programs are strongly personalized and not generic: they are adapted to a particular patient, to regain as much function as possible.

• Commercial video games are a powerful instrument to motivate people. When it comes to therapy, they can help motivate patients.

• While these games are promising for patients in the later stages of recovery, they were designed for users with a full range of motion.
Traumatic Brain Injury (TBI) and Stroke patients have similar disabilities when it comes to trunk control.
STROKE - TBI

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• TBI patients are usually younger, male individuals who were involved in some kind of accident.
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Traumatic Brain Injury (TBI) and Stroke patients have similar disabilities when it comes to trunk control.

- TBI patients are usually younger, male individuals who were involved in some kind of accident.

- Younger individuals have a tendency to enjoy video games, making them an ideal target demographic.
MOBILE WELLNESS GAMES
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• According to Apple’s app store, there are over 11000 apps in the health and fitness category, anything from pedometers to sleep monitors and everything in between.

• Competition and track of progress are big motivators when it comes to exercise. In fact, according to Jawbone, just by tracking an activity, the activity increases by 26%
CURRENT THERAPY DEVICES
• Therapists use a range of devices in rehabilitation therapy, from commercial gaming consoles, to expensive medical devices.
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• When it comes to commercial gaming consoles, those with active sensors to monitor the user are favored over those with just standard controllers.

• Their success varies as games and activities can be challenging to stroke patients.
BACKGROUND WORK
• Development of the Quantitative Trunk Measurement Device (QTCMD) began in early 2010
THE ACCESSORY

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• In order to make the sensor work with touch-enabled devices, such as an iPad, a standard WiFi network needed to be used, so Alex Hastings modified the sensor so it used a standard 802.11 WiFi network.
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• In order to make the sensor work with touch-enabled devices, such as an iPad, a standard WiFi network needed to be used, so Alex Hastings modified the sensor so it used a standard 802.11 WiFi network.
DATA COLLECTION

• A team of physical therapists from two separate hospitals agreed to use the sensor on themselves, as if they were patients.
ANALYSIS OF CURRENT SYSTEMS
CONSUMER DEVICES

- No clinical feedback from experience.
CONSUMER DEVICES

• No clinical feedback from experience.
• Modern console games offer too much visual stimuli.
CONSUMER DEVICES

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• Games are usually designed for the general population.
CONSUMER DEVICES

• No clinical feedback from experience.

• Modern console games offer too much visual stimuli.

• Games are usually designed for the general population.

• Not enough fine-grained control for setting competence levels.
CONSUMER DEVICES

- Therapeutic value of consumer games is low.
CONSUMER DEVICES

• Therapeutic value of consumer games is low.

• Lack of portability.
CONSUMER DEVICES

- Therapeutic value of consumer games is low.
- Lack of portability.
- Expensive in some cases.
CLINICAL EQUIPMENT

- Very few games are available.
- Very expensive and non-portable.
- Requires that the patient is able to stand.
- Clinical feedback √
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OPPORTUNITIES

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• Capable of providing clinical feedback.
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• Highly portable.
• Can be used on a wide range of patients.
• Capable of providing clinical feedback.
• Therapist designed.
• Network capability for remote supervision.
RESEARCH MODEL
A number of game concepts were discussed with the therapists, as well as some basic requirements that they thought should be part of therapeutic games.
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- Stability oriented games.
- Movement oriented games.
STABILITY ORIENTED

For the stability game, the prototype was defined as a “walking” game.
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For the movement game, a similar setting to the stability game will be used, however this time a street or a similar environment is simulated.
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GAME CHARACTERISTICS

It is important for the therapists to modify the characteristics of a game, each patient needs different settings, and possibly, different variations of the same game.
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- Control Configurability.
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It is important for the therapists to modify the characteristics of a game, each patient needs different settings, and possibly, different variations of the same game.

- Control Configurability.
- Content Configurability.
EVALUATION

Based on our discussions with therapists, before the QTCMD sensor and its games can be used with real patients, a feasibility study needed to be performed.
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In order to study the feasibility of the system, the development and evaluation of the project was done in series of iterative prototypes.
EVALUATION

• The prototypes were delivered to therapists at the Mary Free Bed and Hope Network hospitals.
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• After the therapists evaluated the system for a few days, their feedback was collected using an online survey and a personal interview.

• From their suggestions, the prototype was refined for a second round of testing and feedback.
RESEARCH QUESTIONS

• What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?
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• What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?

• Is it feasible to receive the appropriate regiment of therapy from a custom video game?
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• What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?

• Is it feasible to receive the appropriate regiment of therapy from a custom video game?

• Is it feasible that a game can be fully configurable for therapy reasons, and still be fun? How does customizability affect gameplay.
RESEARCH QUESTIONS

• Is it feasible to motivate and engage patients to perform therapy, by using our system?
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• What are the facets of customizability that are needed for a therapeutic game?
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We explored these questions via experimentation and collaboration with domain experts.
IMPLEMENTATION
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• The first prototype was designed with just the game experience in mind (therapy), as well as fully integrating the accessory sensor (and a library to communicate with it) into the app.
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• The first prototype was designed with just the game experience in mind (therapy), as well as fully integrating the accessory sensor (and a library to communicate with it) into the app.

• It implemented the basic game mechanics and configuration options that the therapists suggested in our initial discussions.
ACCESSORY LIBRARY
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• The sensor communicates wirelessly with the iOS device by creating its own ad-hoc Wi-Fi network.
ACCESSORY LIBRARY

• The sensor communicates wirelessly with the iOS device by creating its own ad-hoc Wi-Fi network.

• Communication between the sensor and the iPad is performed using UDP packets on the port 29168.
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• Communication between the sensor and the iPad is performed using UDP packets on the port 29168.

• The sensor has a simple text-based interface for all of its available commands.
ACCESSORY LIBRARY

- The sensor communicates wirelessly with the iOS device by creating its own ad-hoc Wi-Fi network.

- Communication between the sensor and the iPad is performed using UDP packets on the port 29168.

- The sensor has a simple text-based interface for all of its available commands.

- An Objective-C library wraps most of the functionality of the accessory in a single, easy to use class.
MAIN SCREEN
CONTENT CONFIGURABILITY

Visuals

Theme

Scenery ON
CONTENT CONFIGURABILITY

Visuals

Theme

Scenery

ON

Monday, April 30, 12
CONTENT CONFIGURABILITY

Visuals

Theme

Scenery

ON
CONTROL CONFIGURABILITY

**Behavior**

- **Track Length**
- **Laps:** 3
- **Max Speed**
- **Turn Bias (50/50)**
- **Auto Accelerate**
  - On
- **Auto Steer**
  - Off
- **Left/Right Range:** (45°/45°)
CONTROL CONFIGURABILITY

Behavior

Track Length
Laps: 3
Max Speed
Turn Bias (50/50)
Auto Accelerate
ON
Auto Steer
OFF
Left/Right Range: (45°/45°)

Session Settings
Left - Right Range
Symmetrical: ON
PROTOTYPE 2
IMPLEMENTATION
IMPLEMENTATION

• Patient profiles and clinical output.
IMPLEMENTATION

• Patient profiles and clinical output.

• Implementing an assessment tool to measure patient progress.
IMPLEMENTATION

• Patient profiles and clinical output.

• Implementing an assessment tool to measure patient progress.

• Improving game experience developed in the first prototype and providing finer control options.
IMPLEMENTATION

• Patient profiles and clinical output.

• Implementing an assessment tool to measure patient progress.

• Improving game experience developed in the first prototype and providing finer control options.

• The feedback gathered after the therapists had a few weeks to play with the first prototype was taken into consideration and most of their suggestions were incorporated into the new prototype.
MAIN SCREEN
MAIN SCREEN

Restrepo, Alex

No Patient Selected
MAIN SCREEN
ASSESSMENTS
ASSESSMENTS

• An assessment is a combination of measurements of the trunk control of the patient, it contains the initial (natural) position of the patient, as well as a measurement of the limits of stability.
ASSESSMENTS

- An assessment is a combination of measurements of the trunk control of the patient, it contains the initial (natural) position of the patient, as well as a measurement of the limits of stability.
APP SESSION SUMMARY

• Quick summary of the measurements taken in all the sessions that the patient has finished and include: average time off track, average speed, percentage of misses to the left and right (averaged) and the average of the maximum angles recorded for each of the 4 measuring directions.
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SESSION HISTORY

April 4, 2012, 9:54 PM

Total time: 01:49:000
Max Speed: 140%
Max Left: -83°
Avg Left: -14°
Max Back: 1°
Avg Back: 0°
Misses Left: 75%

View Settings

April 4, 2012, 8:43 PM

Total time: 02:22:000
Max Speed: 127%
Max Left: -55°
Avg Left: -13°
Max Back: 0°
Avg Back: 0°

OffTrack time: 00:01:000
Avg Speed: 113%
Max Right: 68°
Avg Right: 11°
Max Front: -69°
Avg Front: -43°
Misses Right: 25%
CONTENT CONFIGURABILITY
CONTENT CONFIGURABILITY

Visuals / Audio

Theme: Car Race
Scenery
Audio

Track

Track Length
Laps: 3
Max Speed
Turn Bias (50/50)
CONTENT CONFIGURABILITY

Visuals / Audio

Theme: Car Race

Scenery

Audio

ON

Off

Track

Track Length

Laps: 3

Max Speed

Turn Bias (50/50)
CONTROL CONFIGURABILITY

Sensor

Auto Accelerate

Fwd/Back Range: (23°/23°)

Flip Front / Back

Auto Steer

Left/Right Range: (45°/45°)

Auto Increase Difficulty

Increment if on track > 89%

Decrement if on track < 80%
CONTROL CONFIGURABILITY
CONTROL CONFIGURABILITY

Sensor

- **Auto Accelerate**
  - **Fwd/Back Range:** (23°/23°)
  - **Flip Front / Back**
  - **Auto Steer**
    - **Left/Right Range:** (45°/45°)
  - **Auto Increase Difficulty**
    - **Increment if on track > 89%**
    - **Decrement if on track < 80%**
RESULTS

Usability, Usefulness, Configurability, Motivation, Clinical Data, General
USABILITY
USABILITY

- Therapists found the device easy to operate. Half of them rated it as very usable, while the other half found it just below the very usable mark.
USABILITY

- Therapists found the device easy to operate. Half of them rated it as very usable, while the other half found it just below the very usable mark.

- From a patient perspective, 75% of the therapists found the device easy to interact with. A high score in ease of use, from the patient side is important in an application where patients can have major cognitive disabilities.
USEFULNESS
USEFULNESS

• 75% of the therapists found the system useful as a therapy tool.
USEFULNESS

• 75% of the therapists found the system useful as a therapy tool.

• From the point of view of the patient, all of the therapists agreed that the device was useful or very useful for therapy.
CONFIGURABILITY
CONFIGURABILITY

• 50% of the therapists found the amount of configurability to good or excellent in prototype 1.
CONFIGURABILITY

• 50% of the therapists found the amount of configurability to be good or excellent in prototype 1.

• 100% of them found the configurability options in prototype 2 to be useful or very useful.
CONFIGURABILITY

- 50% of the therapists found the amount of configurability to good or excellent in prototype 1.

- 100% of them found the configurability options in prototype 2 to be useful or very useful.

- 90% of the settings were used regularly in the test sessions.
• 50% of the therapists found the amount of configurability to be good or excellent in prototype 1.

• 100% of them found the configurability options in prototype 2 to be useful or very useful.

• 90% of the settings were used regularly in the test sessions.

• Prototype 2 introduced uncertainty about how some options worked.
MOTIVATION
• 75% of the therapists rank the system as good or excellent in terms of patient motivation.
MOTIVATION

• 75% of the therapists rank the system as good or excellent in terms of patient motivation.

• 75% of the therapists rank conventional systems as neutral when it comes to patient motivation.
MOTIVATION

- 75% of the therapists rank the system as good or excellent in terms of patient motivation.

- 75% of the therapists rank conventional systems as neutral when it comes to patient motivation.

- 75% of the therapists agree or strongly agree that our system motivates the patients to move more than traditional systems do.
CLINICAL INPUT / OUTPUT
100% of the therapists find the summarized assessment information as useful, however they would like to record more information.
CLINICAL INPUT / OUTPUT

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- “Ease of use is great... simple initial position and few click for right/left anterior/posterior maximal lean.”
CLINICAL INPUT / OUTPUT

• 100% of the therapists find the summarized assessment information as useful, however they would like to record more information.

• “Ease of use is great... simple initial position and few click for right/left anterior/posterior maximal lean.”

• 100% find the session history data as sufficient, that is, the data recorded per session.
GENERAL

• In general, there’s a consensus that the system is feasible as a therapy option and has a lot of potential as a finished product, as well as the fact that it enables a wider range of patients to use it, since there’s no requirement for the patient to stand on a separate device and the patient can easily use the device sitting or standing.
GENERAL

• In general, there’s a consensus that the system is feasible as a therapy option and has a lot of potential as a finished product, as well as the fact that it enables a wider range of patients to use it, since there’s no requirement for the patient to stand on a separate device and the patient can easily use the device sitting or standing.

• Addresses most of the problems with conventional consumer games and clinical devices: portability, cost, ease of use and customized training.
CONCLUSIONS
Q: What are the characteristics of the ideal companion device/accessory for therapeutic games involving TBI patients?
Q: What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?

- Configurability of content and control.
Q: What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?

- Configurability of content and control.
- Ease of use.
Q: What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?

- Configurability of content and control.
- Ease of use.
- Portability.
Q: What are the characteristics of the ideal companion device / accessory for therapeutic games involving TBI patients?

- Configurability of content and control.
- Ease of use.
- Portability.
- Price.
Q: Is it feasible to receive the appropriate regiment of therapy from a custom video game?
Q: Is it feasible to receive the appropriate regiment of therapy from a custom video game?

- Therapists agree on the fact that the system has a lot of potential, and can definitely help them when it comes to provide therapy to a TBI patient.
Q: Is it feasible to receive the appropriate regiment of therapy from a custom video game?

- Therapists agree on the fact that the system has a lot of potential, and can definitely help them when it comes to provide therapy to a TBI patient.

- "I do think there's a lot of potential but would need to see it on actual patients to really be sure"
Q: Is it feasible to receive the appropriate regiment of therapy from a custom video game?

- Therapists agree on the fact that the system has a lot of potential, and can definitely help them when it comes to provide therapy to a TBI patient.
  
- "I do think there's a lot of potential but would need to see it on actual patients to really be sure"

- Clinical trials with real patients are necessary to confirm what therapists have experienced in our tests
Q: Is it feasible that a game can be fully configurable for therapy reasons, and still be compelling to the patient? How does customizability affect gameplay?
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- The games seem to be a motivation factor for patients to engage in therapy.
Q: Is it feasible that a game can be fully configurable for therapy reasons, and still be compelling to the patient? how does customizability affect gameplay?

• The games seem to be a motivation factor for patients to engage in therapy.

• Part of the reason for this motivation is that the game can be fine-tuned to the abilities of the patient, in such a way that it’s appealing to even patients with severe limitations.
Q: Is it feasible to motivate and engage patients to perform therapy, by using our system?
Q: Is it feasible to motivate and engage patients to perform therapy, by using our system?

- When the therapists were asked about the apparent motivation to use the system, 75% of them ranked it as good or excellent in terms of motivation.
Q: Is it feasible to motivate and engage patients to perform therapy, by using our system?

- When the therapists were asked about the apparent motivation to use the system, 75% of them ranked it as good or excellent in terms of motivation.
- "Yes, I think it's a great concept and my patients enjoyed using it as well. There are a lot of great features already in the product..."
Q: What are the facets of customizability that are needed for a therapeutic game?
Q: What are the facets of customizability that are needed for a therapeutic game?

• Content Configurability:
  Being able to target the sensory feedback to the appropriate level for the patient.
Q: What are the facets of customizability that are needed for a therapeutic game?

• Content Configurability:
  Being able to target the sensory feedback to the appropriate level for the patient.

• Control Configurability:
  The ability to normalize and modify the patient input so different levels of disability can still get comparable levels of performance.
Q: Is it feasible?
Q: Is it feasible?

- Based on our findings and our discussions with the experts, we can state that our prototypes were successful at providing therapeutic experiences, while delivering useful data for the therapists.
Q: Is it feasible?

• Based on our findings and our discussions with the experts, we can state that our prototypes were successful at providing therapeutic experiences, while delivering useful data for the therapists.

• “...This system definitely has strong potential for the rehab market due to its portability, low cost, user friendly, customized training, and intuitive gaming components...”
Q: Is it feasible?

- Based on our findings and our discussions with the experts, we can state that our prototypes were successful at providing therapeutic experiences, while delivering useful data for the therapists.

- “...This system definitely has strong potential for the rehab market due to its portability, low cost, user friendly, customized training, and intuitive gaming components...”

- “...In the beginning, I strongly felt that there lacked a therapy device that assisted with treatments for a wide range of clients (those who could only sit, vs. those who can only stand, vs. those who need work on balance during movement). I think this device is hitting a wide range of clients and could expand more to those who need balance training within the context of movement.”
FUTURE WORK
FUTURE WORK
FUTURE WORK

Richer, moving visuals
FUTURE WORK

Road Signs
FUTURE WORK

Make the on track measurement be more forgiving the richer the visuals are on
FUTURE WORK

Being able to offset the zero value for the angles
FUTURE WORK

Some sort of backpack or harness for the unit
FUTURE WORK

Preprogrammed tracks that vary in difficulty
FUTURE WORK

Variable track width
FUTURE WORK

Separate vibration from beeps
FUTURE WORK

Remote dashboard
FUTURE WORK

Comparative Graphs
FUTURE WORK

Bluetooth 4 Integration
FUTURE WORK

Gyroscopes
FUTURE WORK

In-App Documentation
FUTURE WORK

Visual clues on how to go back on track
FUTURE WORK

Pause
FUTURE WORK

Calibration screen
FUTURE WORK

Programmable calibration
FUTURE WORK

Practice runs
FUTURE WORK

Leaderboards
QUESTIONS?

Thank you