

Game-Based Stroke TeleRehabilitation: Challenges in Scaling to National Clinical Trails

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Overview

- UCI StrokeNet team
- Challenges of Stroke Rehabilitation, Telerehabilitation and Games
- Developing, demonstrating and deploying Game-Based Stroke Telerehabilitation systems
- UCI Stroke Telerehab system and environment
- Further scaling challenges
- Conclusions
- ClinicalTrials.gov: [NCT02360488](https://clinicaltrials.gov/ct2/show/study/NCT02360488)

UCI *StrokeNet* team

- Steve Cramer, MD (PI): Neurology, Anatomy & Neurobiology, and Physical Medicine & Rehabilitation, UCI School of Medicine; NINDS *StrokeNet* Exec. Committee
- Lucy Dodakian (OTR/L), Allison McKenzie (DPT), Jill See (PT), Jutta Heckhausen (Psych. & Soc. Beh.), Vu Le (software dev), and others.
- Collaborators and patient recruitment at eight national *StrokeNet* hospitals

***StrokeNet* Clinical Trial Partner Sites**

Parent StrokeNet RCC	Study Site
Los Angeles Southern California	University of California, Irvine
Northwest Stroke Trials Network	Harborview Medical Center
Chicago Stroke Trials Consortium	Rehabilitation Institute of Chicago
Cleveland Regional Coordinating Center	MetroHealth Rehabilitation Institute of Ohio
Georgia StrokeNet	Emory Rehabilitation Hospital
South Carolina Collaborative Alliance for Stroke Trials	MUSC Center for Rehabilitation Research in Neurological Conditions
Stroke Trials Network of Columbia and Cornell	Burke Rehabilitation Hospital
New England Regional Coordinating Center	Spaulding Rehabilitation Hospital

About me:

Research Director, UCI IVECG

- Focused on producing Computer Games and Game-Based Virtual Worlds since 2005 for:
 - Academic research (National Science Foundation)
 - GBVW as Decentralized Activity Systems (2008-12)
 - *Computer Games and Software Engineering* (2015).
 - Industrial training (Intel—*Semi.Fab*, “NDA”—*drug discovery*)
 - K-12th *STEAM education* (Discovery Science Center, San Francisco Symphony)
 - Defense (USNavy, Northrop-Grumman—C2/C3CB) and Healthcare (NINDS-*stroke*; UCI ICTS-*asthma*)
 - International R&D partnerships (SKorea, UK)

Recent Project: *SFSKids.org* – Informal Classical Music Learning Game Environment

SFSKIDS
FUN & GAMES WITH MUSIC

Discover Music

Under the Sea of Knowledge.



Play with Music

Above the Musical Skies



Perform Music

In the Instrument Garden



Conduct Music

At the Symphony Hall



Compose Music

Atop the Mountain of Muses



Challenges of Stroke Rehabilitation, Telerehabilitation and Games

Stroke and Stroke Rehabilitation

- Approx. 800K/yr. stroke survivors in US, ~65% with persistent motor control impairments.
- Unassisted motor control *recovery is partial*.
- Clinical rehabilitation focuses on *activities of daily living* (ADLs) via occupational therapy.
- Most therapy *requires at-home, iterative practice*.
- Approx. 33% of all stroke patients experience *clinical depression*.
- *Low rates* of therapeutic compliance.

Stroke Telerehabilitation

Research Question: *How best to utilize computer games and networked information technology to deliver personalized stroke rehabilitation therapy and assessment to patients at home?*

UCI Stroke Telerehabilitation

- Goal: Provide *low-cost* rehabilitation capabilities and stroke prevention education for at-home usage.
- Goal: *Minimize complexity* of support system feature and interaction, and *enable fun* user experience.
- Goal: *Supporting (remote) therapists and physicians*: building on not replacing modern rehabilitation.
- Goal: Utilize *standardized* stroke/motor control *outcome measures*, education and patient *assessments*.
- Goal: Insure patient *safety*, *non-inferiority*, and HIPPA *privacy* and data *security* compliance.

Game-Based Stroke Rehabilitation and Telerehabilitation: *Translational* Challenges

- Many promising demonstration projects.
 - Games provide *intrinsic motivation* for activity/play, but
 - Most research to date are singular case studies of technology development; some without stroke patients.
- Few clinical assessments, few/no recovered ability assessments or validation after sustained post game-play intervention.

Game-Based Stroke Rehabilitation: *Translational Challenges*

- Identify *theory/model* underlying motor control impairment, neuroplasticity and recovery.
- Identify what *motor control circuits* or *therapeutic movements* addressed.
- Identify mapping for *patient-specific impairments* or rehabilitation plan via differentiated game play.

Developing, Demonstrating and Deploying Game-Based Stroke Telerehabilitation systems

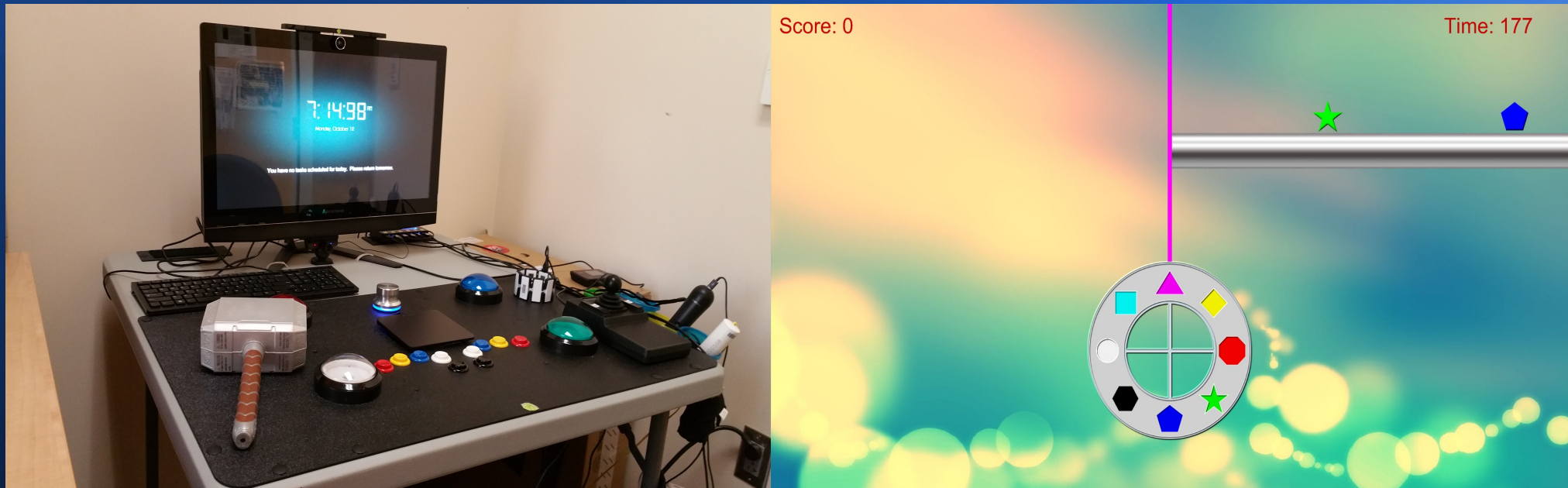
UCI Stroke Telerehabilitation system and environment

- Upper extremity motor control *game console*
 - 9 types of movement interaction *devices*
 - 8 kinds of *upper extremity movements*, and 96 standard motor control rehabilitation exercises
 - 25 *mini-games* addressing different motor control tasks.
 - Open to improvements, extensions, repurposing, including anything that can be transduced, then measured and trained.
- Therapist UI/UX support system environment
 - Clinical trial management system infrastructure

UCI Stroke Telerehabilitation game console



Stroke Telerehabilitation game console and a sample game (for dial rotation movement)

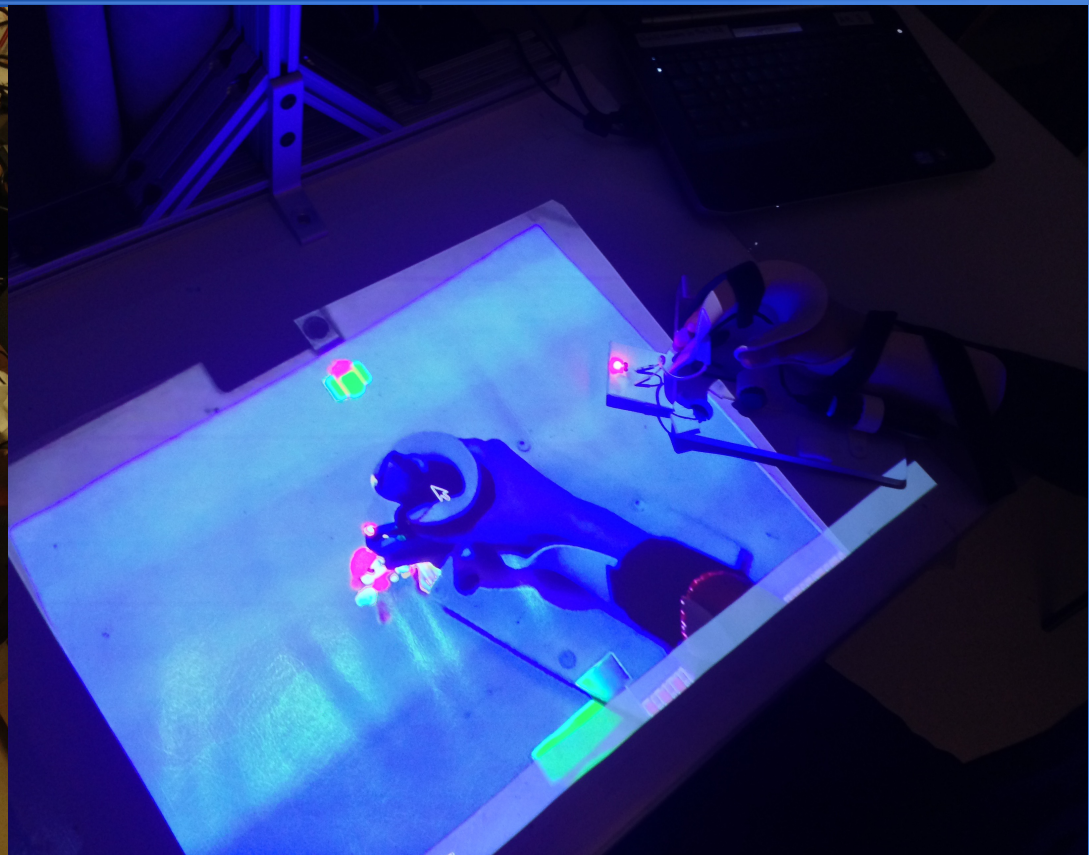


Motor control devices: Game console buttons (large, small), continuous dial, Myo armband, touchpad, joystick, WiiMote, PS Eye, finger pressure force sensor.

All devices integrated to act like PC mouse/keyboard inputs.

35 consoles currently deployed in nationwide clinical trial.

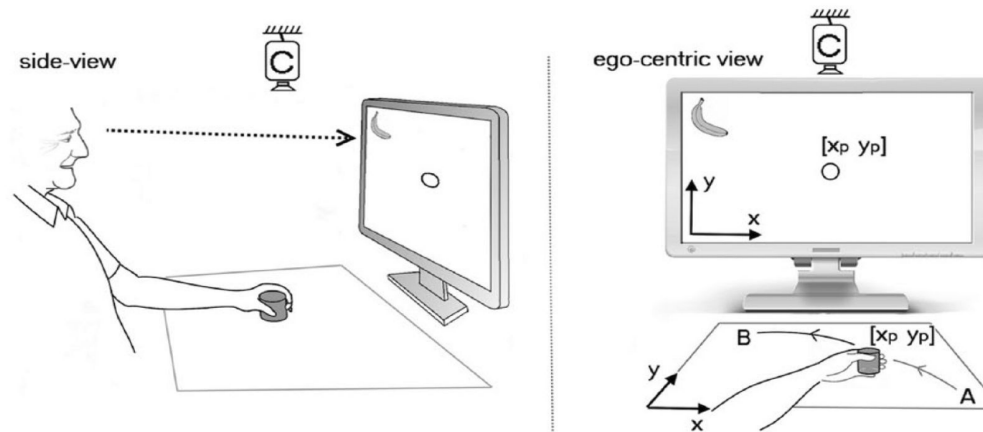
Extension candidate: AR Stroke Rehab Game Interface



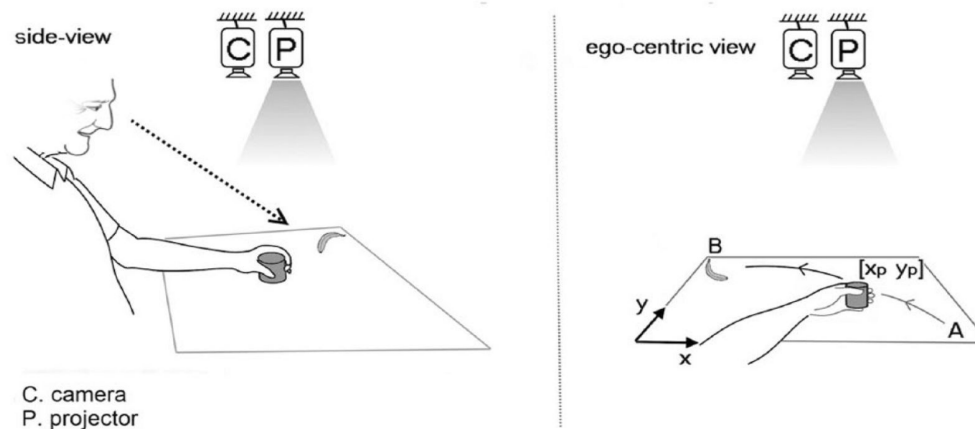
(a) 1st person view, (b) functional tasks with high ecology and affordance, (c) mirror neural activation, (d) embodied action observation/priming, (e) explicit motor imagery, (f) playful interaction experience and (g) safety.

Extension candidate: PC versus AR stroke rehabilitation game play UI/UX efficacy

A. Personal computer version of the game



B. Augmented reality version of the game



AR user interface associated with ~20% improved therapeutic movement accuracy (positional score), reaction times, and 15% less movement variability vs. PC UI.

Therapist Control Panel UI

UC IRVINE TELEREHABILITATION STROKE STUDY



Treatment
Planner



Daily
Note



Hardware
Tracking



Stroke Education
Scores



O.P.S, P.A.C.E.S.,
Patient Satisfaction
Scores



Patient
Performance



Newsletters &
Documents



Therapist
Feedback



Logout

Control Panel: Patient Itinerary

UC IRVINE TELEREHABILITATION STROKE STUDY

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Choose An Activity

▶ Decreased proximal strength

▶ Decreased distal strength

▼ Decreased grip strength

▶ Exercises

▼ Games

Flappy Bird

Targeting

▶ Decreased pinch strength

▶ Decreased prox motor control

▶ Decreased distal motor control

▶ Decreased fine motor control

▶ Other



VuTest (TR Group)
Supervised Session #1
10/5/2015

Start Time: 10:00am

Video Chat - Review (10/10 minutes)

⬆ ⬇ Video Chat ✕

Exercises (10/10 minutes)

⬆ ⬇ 3 Transfer Object (73) ✕

⬆ ⬇ B Shldr Horiz Abd w/Tubing (99) ✕

⬆ ⬇ Bilat Elbow Flexion (52) ✕

Games (10/10 minutes)

⬆ ⬇ Bubble Pop ✕

⬆ ⬇ Cut the Rope ✕

Anything (10/10 minutes)

⬆ ⬇ All Finger Ext (33) ✕

⬆ ⬇ Targeting ✕

Break (10/10 minutes)

Current Itinerary for VuTest

Uploaded

Total time: 80 Minutes

- Video Chat: 10 minutes
- 3 Transfer Object (73): 2 minutes
- B Shldr Horiz Abd w/Tubing (99): 3 minutes
- Bilat Elbow Flexion (52): 5 minutes
- Bubble Pop: 5 minutes [PS Move]
- Cut the Rope: 5 minutes [PS Move]
- All Finger Ext (33): 5 minutes
- Targeting: 5 minutes [Squeeze]
- Rest: 10 minutes
- Fingers MP Ext Stretch (57): 5 minutes
- MP Ext IP Flex (56): 5 minutes
- Flappy Bird: 10 minutes [Buttons]
- Button Presses: 5 minutes [Buttons]
- DIP Extension Stretch (58): 5 minutes

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Control Panel: Therapy Plan

UC IRVINE TELEREHABILITATION STROKE STUDY

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TR Group
Supervised Session #1
10/5/2015

Total time: 80 Minutes

- Video Chat
 - 10 minutes
- 73. 3 Transfer Object
 - 2 minutes

Exercise # 73: Transfer Object



Grasp and hold object with one hand. Transfer object to other hand. Reverse. Use objects of different shapes, sizes and weight.

- 99. B Shldr Horiz Abd w/Tubing
 - 3 minutes

Exercise # 99: Bilateral Shoulder Horizontal Abduction With Tubing

Hold band with palms facing in and arms extended. Keep arms straight while pulling both arms out to the sides, squeezing shoulder blades together.



- 52. Bilat Elbow Flexion

Recipient Email:

[Send Email](#)

Control Panel: Patient Survey Assessment

UC IRVINE TELEREHABILITATION STROKE STUDY

Main Menu

O.P.S.					
<u>Date</u>	<u>Visit</u>	<u>Time</u>	<u>Subject ID</u>	<u>Individual Answers</u>	<u>Total Score</u>
10/1/2015	Baseline	5:42:07 PM	Therapist	7,5,3,4,5,6,6,5,7,4,5,5	62
10/2/2015	Baseline	2:49:38 PM	dovj	4,4,4,4,5,5,4,5,5,4,4,5	53
10/8/2015	Week 3	12:30:16 PM	verd	7,1,7,1,7,7,7,7,7,7,7,7	72
10/12/2015	Baseline	10:36:23 AM	VuTest		0

P.A.C.E.S					
<u>Date</u>	<u>Visit</u>	<u>Time</u>	<u>Subject ID</u>	<u>Individual Answers</u>	<u>Total Score</u>
10/2/2015	Baseline	2:52:50 PM	dovj	3,3,4,4,4,3,4,4	29
10/8/2015	Week 3	11:32:57 AM	verd	7,7,7,7,7,7,7,7	56
10/12/2015	Baseline	10:36:27 AM	VuTest		0
10/19/2015	Week 3	11:00:26 AM	vhle	5,5,4,3,5,4,3,5	34

Patient Satisfaction					
<u>Date</u>	<u>Visit</u>	<u>Time</u>	<u>Subject ID</u>	<u>Individual Answers</u>	<u>Total Score</u>
10/1/2015	Week 3	5:53:49 PM	Therapist	4,5,3,5,4,3,4,4,4,3	39
10/2/2015	Week 3	2:56:21 PM	dovj	3,4,4,4,4,4,4,4,4,4	39
10/8/2015	Week 6	12:28:38 PM	verd	7,7,7,7,7,4,7,7,7,7	67
10/12/2015	Week 3	10:35:51 AM	VuTest		0

Further stroke telerehabilitation scaling challenges

- Improve, extend, repurpose game console and/or environment.
- Persistent, *social multi-patient* therapeutic game play
 - Socialize telerehab and peer engagement play
 - Enable communication (text+*Emoji* chat) with peers
 - Enable cooperative, coordinative, and collaborative game play.
- How best to support *thousands* of stroke patients?
- How best to take advantage of multi-timezone support for patients needing 24 hours rehabilitation care.

Conclusions

- Game-based stroke telerehabilitation is rapidly evolving and large opportunity area for research that translates into clinical practice.
 - Focus to date is stroke, but can extended to other chronic disease management: diabetes, obesity, dementia, medication compliance.
- Stroke telerehabilitation system and environment are scalable, personalized, fun to use in therapeutic care and participatory.
- Game-based stroke telerehabilitation can be deployed with international research or clinical practice partners.

Acknowledgements

- NIH/NINDS
- ClinicalTrials.gov: NCT02360488,
[Telerehabilitation in the Home Versus Therapy In-Clinic for Patients With Stroke An Assessor-blind, Randomized, Non-inferiority Trial](#)