

# [THIS TALK IS JUST A PROXY]

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# Aotearoa New Zealand

- ❑ Population: ~5 million
  - ~1.7m in Auckland
  - ~400k in Christchurch
  - ~400k in Wellington
  - ~30m sheep
  - ~12m cows
- ❑ Huge empty, lush space
  - Lots of Hobbits
  - Few Orcs









# One More Quick Word...



Rob Lindeman, HIT Lab NZ ([gogo@hitlabnz.org](mailto:gogo@hitlabnz.org))

# Human Interface Technology Lab NZ



- ❑ At University of Canterbury
  - Christchurch, NZ
  - College of Engineering
- ❑ Founded in 2002
  - VR/AR Pioneers Tom Furness & Mark Billinghurst
- ❑ Largest interaction lab in NZ
  - 45-60 Researchers at any given time
- ❑ Multidisciplinary
- ❑ Research and Teaching
  - Masters & PhD Programmes



# HIT Lab NZ / Applied Immersive Gaming Staff



Prof Rob Lindeman



A/Prof Heide Lukosch



Prof Andy Phelps



Prof Stephan Lukosch



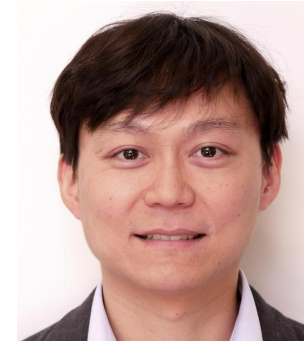
A/Prof Christoph Bartneck



Dr Adrian Clark



Dr Simon Hoermann



Dr Tham Piumsomboon

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Rob Lindeman, HIT Lab NZ ([gogo@hitlabnz.org](mailto:gogo@hitlabnz.org))

# HIT Lab NZ Philosophy



- ❑ We Put People Before Technology  
*Hangarau Tangata, Tangata Hangarau*
- ❑ Start with the **person**...
- ❑ ...look at the **tasks** they are trying to perform...
- ❑ ...look at the **environment** they are in...
- ❑ ...apply appropriate **technologies** to support them in their work, learning, etc.

# Who Am I?



## ❑ Prof Robert W. Lindeman (“Rob”)

- Professor of Human-Computer Interaction
- Director, Human Interface Technology Lab NZ
- Research interests
  - Multi-sensory VR (see, hear, smell, touch, taste)
  - Long-term immersion (reduce fatigue, get real work done)
  - Very applied work (solve real-world problems)

## ❑ Like to play

- 3D Action/Platformers/Story (Now: “*Horizon: Zero Dawn*”)
- Racing games
- Geocaching: GPS treasure hunting in the real world
  - <http://www.geocaching.com/>
  - But that’s another talk...



# Why I Got Into VR...

## ❑ As a kid

- *Space. The final frontier...* (b. 1965)
- Loved science fiction
- Not the best student in grade school
- Studied computer science in college
- Optimistic

## ❑ As an adult

- After Uni, took a “normal” job for 6 years (in Germany, 1987-1992)
- Took a chance: Went back to do a PhD (1993-1999)
- ⇒ Result: Best job in the world!

# Best Job in the World?



- ☐ I teach and work with students on
  - VR/AR/MR
  - Cutting-edge interfaces
  - Video-game design and development
- ☐ Traveled to Japan every summer for 14 years for work
- ☐ Give talks at conferences/workshops
- ☐ VR researchers are a good bunch!
  - Transparent paper review process
  - Lots of sharing of ideas
  - Generally optimistic people
- ☐ Went to Antarctica (twice!) to work on 360-video VR capture
- ☐ Now: I live in NZ! 😊

# Also...



- ❑ Summers of 2002-2007, Visiting Researcher at **ATR** in Kyoto, Japan
- ❑ Summers of 2008-2010, 2013-2014, Visiting Researcher at **Osaka University** (Kishino Lab & Takemura Lab) [Co-authors with Milgram on the R-V Continuum]
- ❑ July 2011-June 2012, Erskine Fellow, **HIT Lab NZ**
- ❑ Summer 2012, Visiting Researcher at Kato lab at **NAIST**, Nara, Japan
- ❑ Program Chair, IEEE VR 2009
- ❑ General Conference Chair, IEEE VR 2010 & 2011
- ❑ Program Chair IEEE ISMAR 2014 & 2015
- ❑ Symposium Chair IEEE 3DUI 2014-2016
- ❑ IEEE VR 2022 in Christchurch!!      ← Come!

# Proxies are a Nice Area of Research: Lots of Juicy Problems!



- ☐ Identifying potential physical objects
  - Location/shape/meaning
- ☐ Matching physical shapes to VR shapes
- ☐ Creating contextual representations
- ☐ Tracking physical movements
- ☐ Mapping physical movements to VR changes
- ☐ Managing multiple physical objects



# Taking a Step Back...

- ❑ What is the high-level goal?
  - What problem/task are we addressing/supporting?
  - General? Special purpose?
- ❑ Use of everyday objects is very attractive!
  - Familiarity/universality
  - Availability
  - “Cheap” haptic feedback

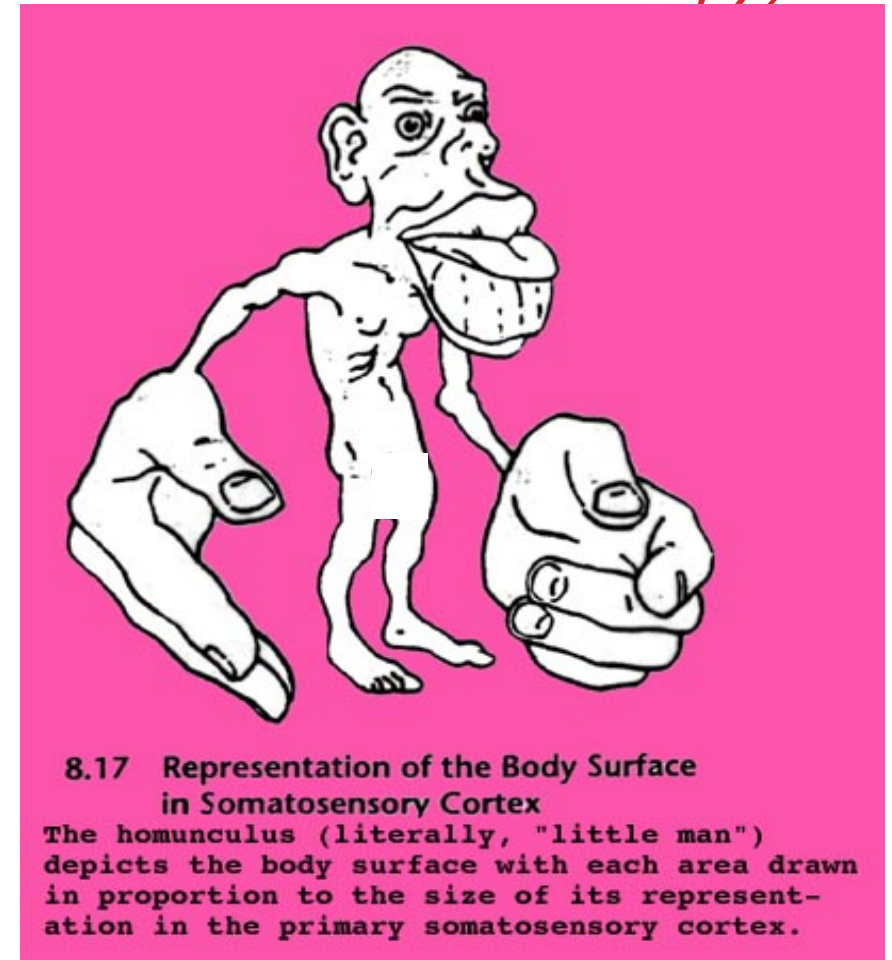
# Taking a Step Back...



- ☐ Are proxy objects the answer to everything?
- ☐ SPOILERER: Probably not! 😊
- ☐ How can we fit their use into a larger haptics framework?

# Haptic Feedback in VR

- ❑ Tactile: Surface properties
  - Most densely populated area is the fingertip (okay, it's the tongue)
- ❑ Kinesthetic: Muscles, Tendons, etc.
  - Also known as proprioception
- ❑ Proxy objects influence both!



# Haptics: Very Complex!



- ❑ Haptics: Sense of touch
- ❑ Actually covers many different senses
  - Force/pressure
  - Slipperiness
  - Vibration
  - Wind
  - Temperature
  - Pain
  - Proprioception
  - Balance (?)

# Skin Sensitivity

- Sensitivity varies greatly
  - Two-point discrimination



<http://faculty.washington.edu/chudler/chsense.html>

Body Site	Threshold Distance
Finger	2-3mm
Cheek	6mm
Nose	7mm
Palm	10mm
Forehead	15mm
Foot	20mm
Belly	30mm
Forearm	35mm
Upper Arm	39mm
Back	39mm
Shoulder	41mm
Thigh	42mm
Calf	45mm





# Haptic Sensory Properties

- ❑ The haptic sense is bidirectional
  - **Senses** the environment
  - **Acts** on the environment
  - Tight coupling between the two
- ❑ Skin is the largest organ

# Passive Haptics Defined

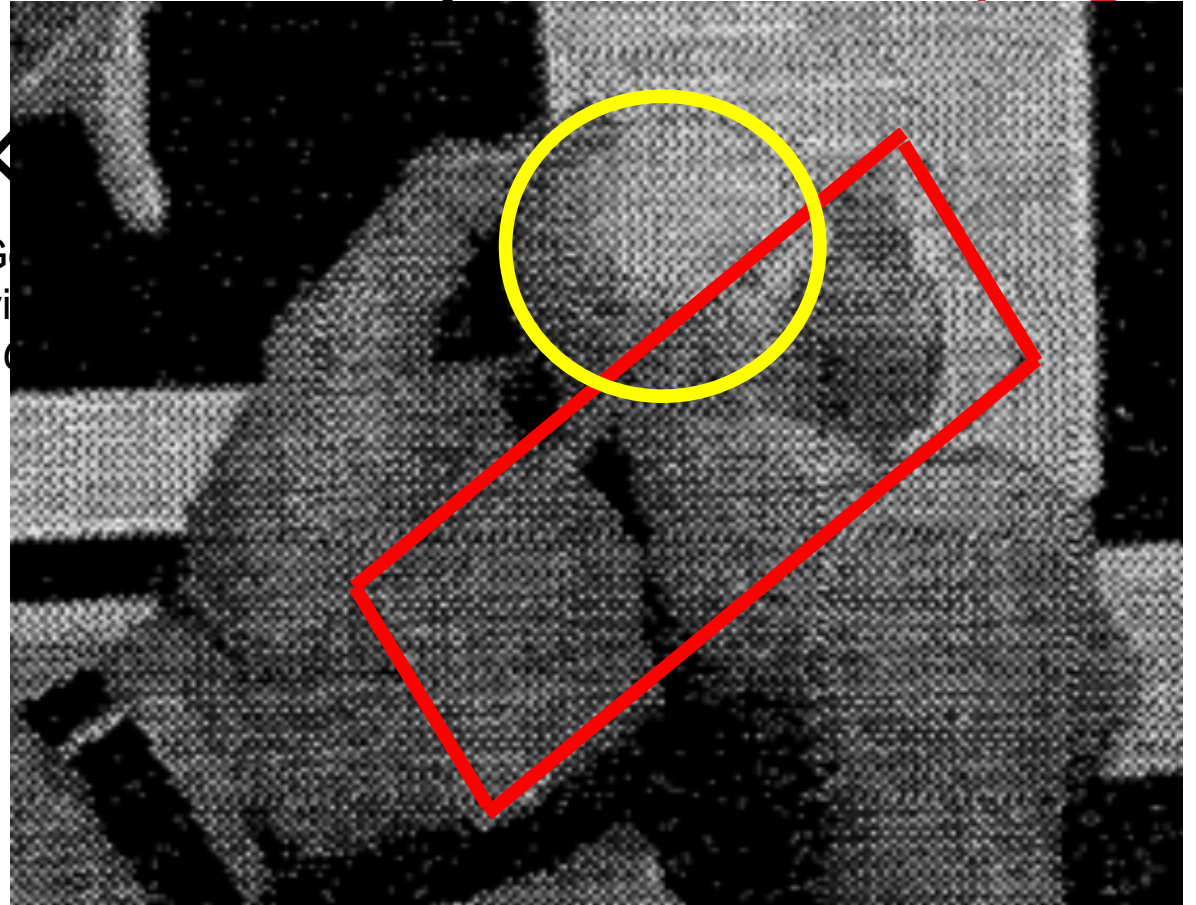


- ❑ “Haptic interfaces provide stimuli to the receptors serving the sense of touch. In general, haptic interface devices can be broken down into several groups. The main distinction can be made between *active* and *passive* devices.”
- ❑ “Passive-haptic ‘devices’ are physical objects which provide feedback to the user simply by their shape, texture, or other inherent properties. In contrast to active-haptic feedback systems, the feedback provided by passive-haptic feedback devices is not controlled by a computer. These objects can be either rigid or deformable.”

R.W. Lindeman. 1999. *Bimanual interaction, passive-haptic feedback, 3d widget representation, and simulated surface constraints for interaction in immersive virtual environments*. Ph.D. Dissertation. The George Washington University. pp. 19-20.



**Figure 1:** A User Selecting a Cutting-Plane with the Props.



# User Interface Support

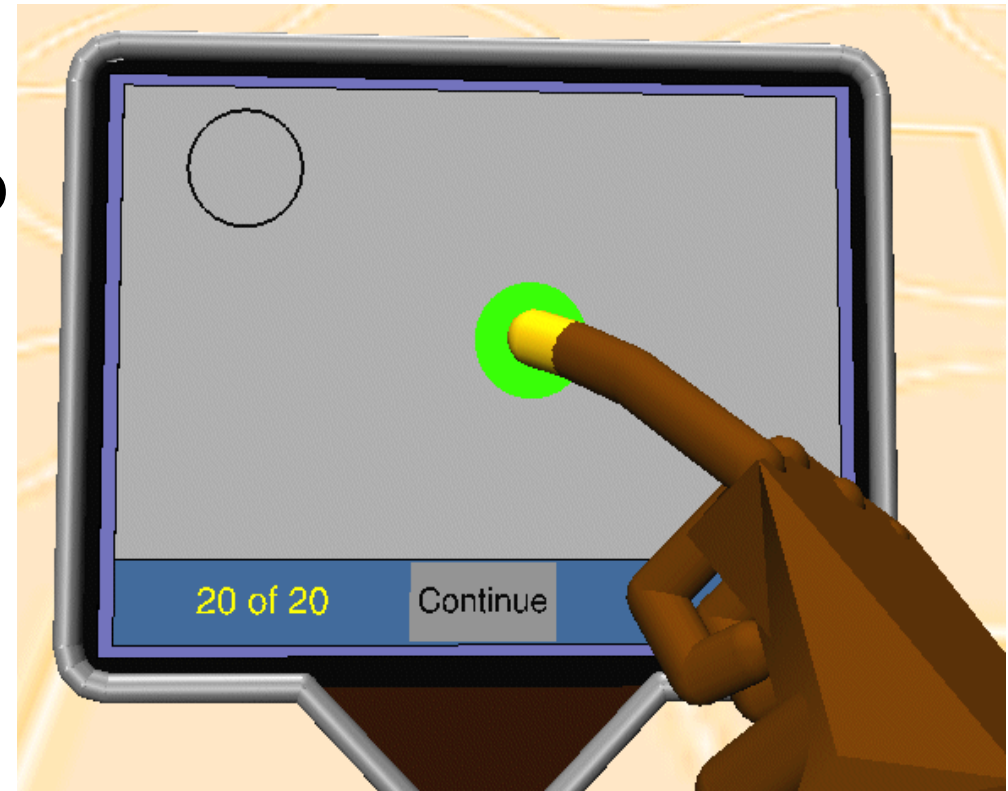


- ❑ I wanted to see if this approach could support *general user interaction*
  - 2D in 3D
- ❑ Two main points:
  - Passive Feedback
  - Bi-manual interaction

# The Haptic Augmented Reality Paddle (HARP) System [1996-1999]



- ❑ Track a passive surface
- ❑ Track the user's fingertip
- ❑ 2D UI elements on VR surface





**Hand–Held Windows:  
Towards Effective 2D Interaction  
in Immersive Virtual Environments**

**Robert W. Lindeman**

**John L. Sibert**

**James K. Hahn**

**The George Washington University**

R. W. Lindeman, J. L. Sibert and J. K. Hahn, "Hand-held windows: towards effective 2D interaction in immersive virtual environments," *Proc. IEEE Virtual Reality*, 1999, pp. 205-212.

# Series of User Studies



	<b>Hand-Held (H)</b>	<b>World-Fixed (W)</b>		
<b>Passive Haptics (P)</b>	HP Treatment	WP Treatment	<b>2D Widget Representation (2)</b>	<b>3D Widget Representation (3)</b>
<b>No Haptics (N)</b>	HN Treatment	WN Treatment		
			<b>Physical Surface (P)</b>	<b>3P Treatment</b>
			<b>Clamped Surface (C)</b>	<b>3C Treatment</b>
			<b>No Surface (N)</b>	<b>3N Treatment</b>

# Main Results



- ❑ Bi-manual+Passive Haptics was best
- ❑ Note: Most VR menu interaction used (and still uses) one hand and no haptics, which was the worst approach.



# What About the Other Haptics?

- ☐ Actually covers many different senses
- ☐ Force/pressure
- ☐ Slipperiness
- ☐ Vibration
- ☐ Wind
- ☐ Temperature
- ☐ Pain
- ☐ Proprioception
- ☐ Balance (?)



# Adding Wind: TactaFans

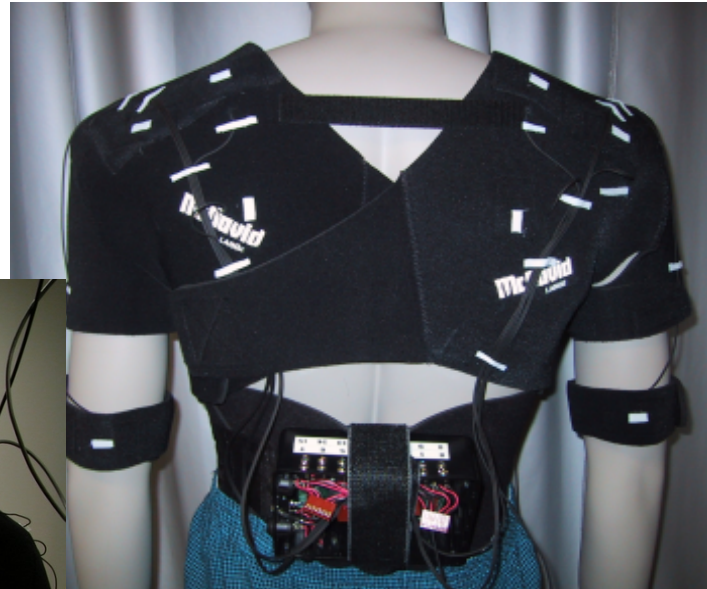
- ❑ Typically, the user sees/hears
  - Grass moving
  - Trees swaying
  - Fire burning
- ❑ We add wind synchronized with the visual/sound cues to complete the experience
- ❑ Solved the “turn wind off fast” problem



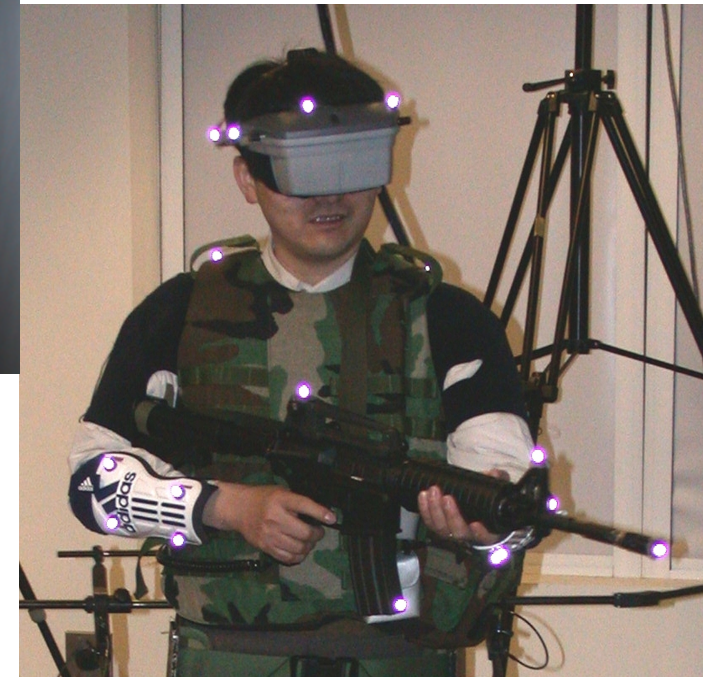
# Adding Floor Vibration

- ❑ Typically, the user sees/hears...
  - Object/object contacts
  - Explosions
  - His/her footsteps
- ❑ We add wearable & floor vibration synchronized with the visual/sound cues to complete the experience
- ❑ TactaVest vibration based on
  - User contact with environment
  - Explosions

# Wearable Haptics: TactaVest

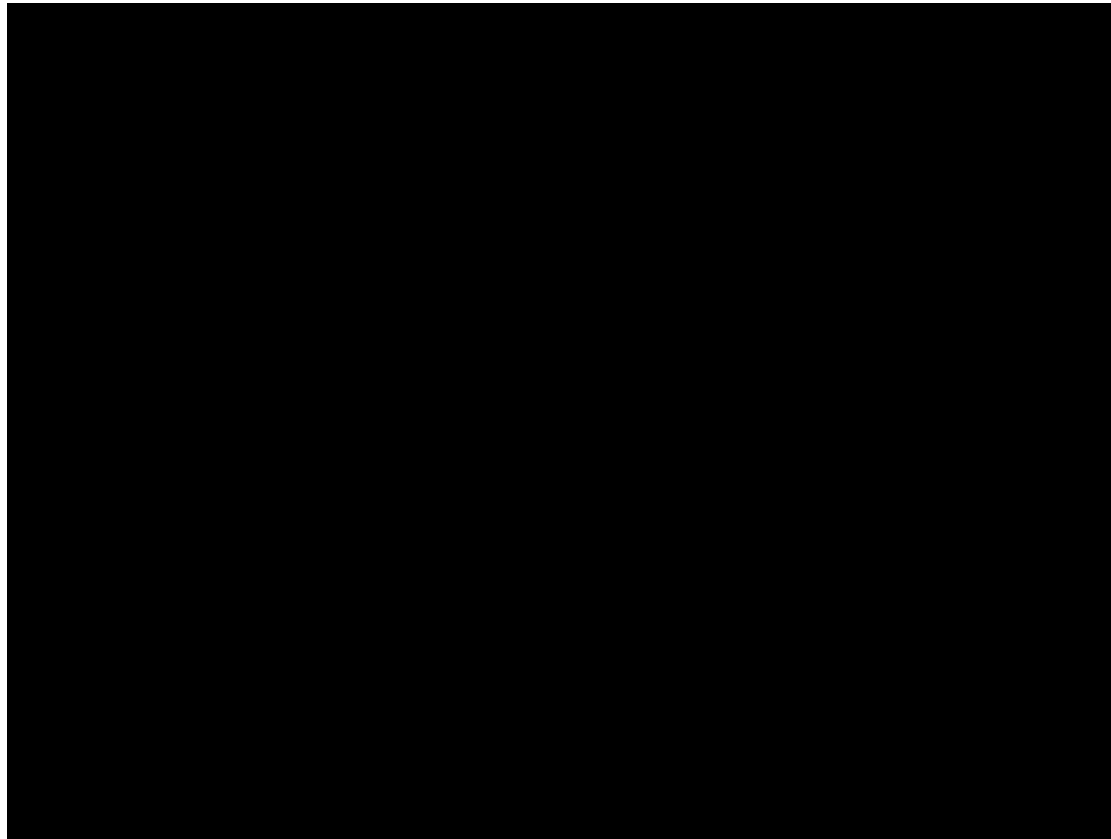


**TactaVest**



# Haptic ChairIO

[Feng et al., IEEE 3DUI 2016]



# TactaCage (IEEE VR 2010)



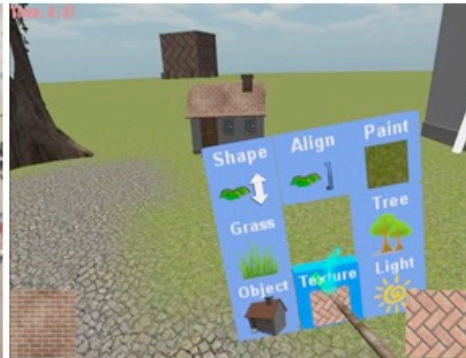
Rob Lindeman, HIT Lab NZ ([gogo@hitlabnz.org](mailto:gogo@hitlabnz.org))

# Hybrid Virtual Environments

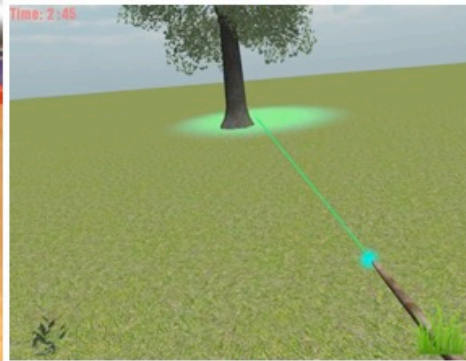
[Wang et al., IEEE 3DUI 2013]



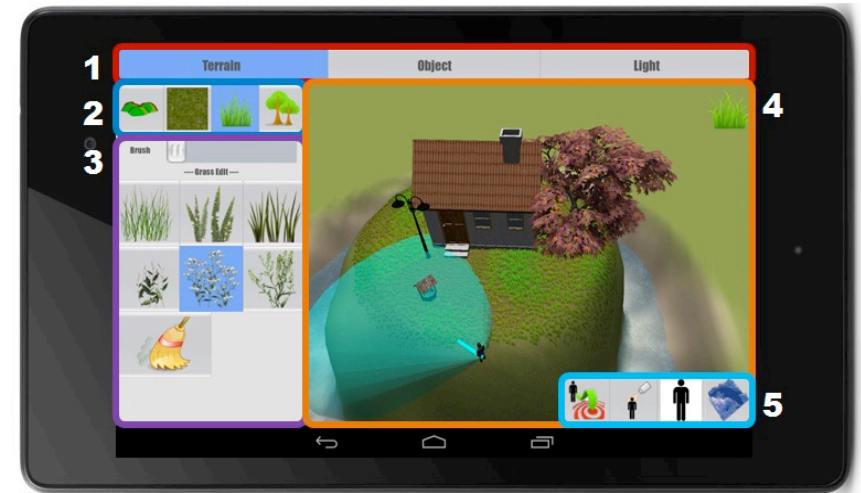
(a)



(b)



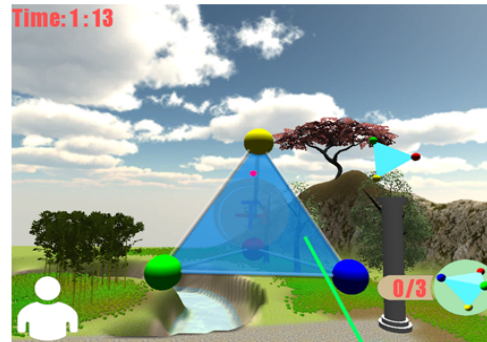
(c)



# Comfortable VR Work: Object Impersonation [Wang et al., IEEE VR 2015]



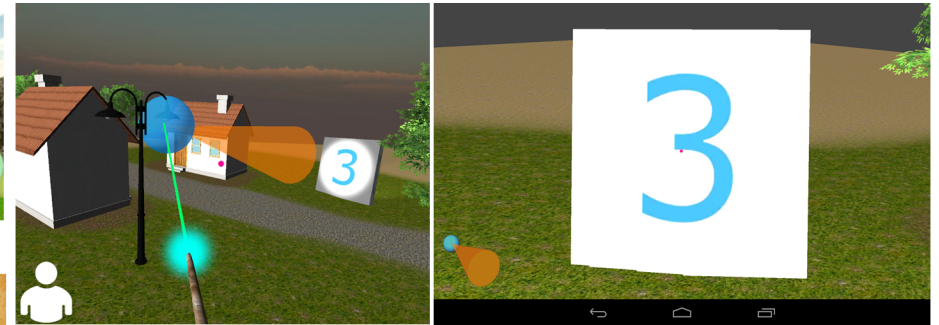
(a)



(b)



(c)



(a)

# Improving Comfort in VR: Dynamic Immersion [Lindeman, IEEE VR 2016]

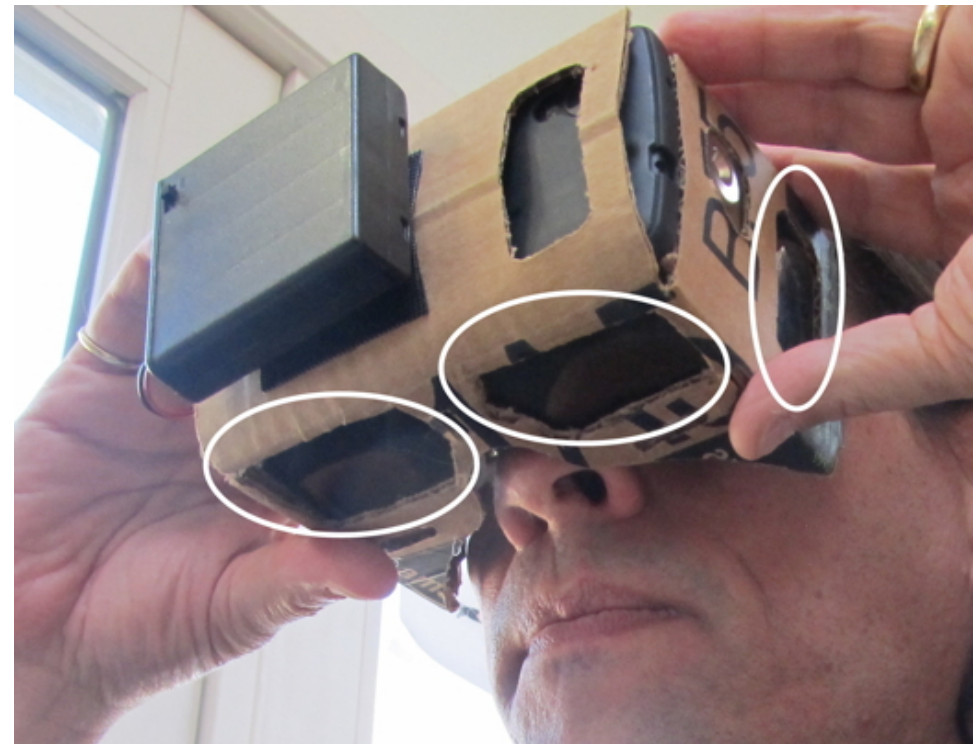


## ❑ Control with:

- Software
- Sensors
- Buttons/slider

## ❑ Lots of uses:

- Reduce cybersickness
- Drink your tea
- Answer phone
- Be a better office worker
- Use your keyboard and mouse



# Enough From Me!



- ❑ Shakiba: Re-use a single proxy object!
- ❑ Donald: “Interest is growing...” Nice! 😊
- ❑ Tim: Reduce both virtual & physical clutter!
- ❑ Tobias: Cake shaping. Epic! (note: have a look at shape-tape too)
- ❑ Denise: AR Proxy objects. A hard problem!

# Enough From Me! (cont)



- ☐ Felix: Proxy sports also seems cool!
- ☐ Akhmajon: Smart objects made smarter!
- ☐ Uli: Perceptual tolerances for R & V objects!
- ☐ Niels: Nice criteria!
- ☐ Julius: Nice discussion in the paper!
- ☐ Carolin: Smart use of a smartwatch!

# Back to Proxies and those Juicy Problems!



- ☐ Identifying potential physical objects
  - Location/shape/meaning
- ☐ Matching physical shapes to VR shapes
- ☐ Creating contextual representations
- ☐ Tracking physical movements
- ☐ Mapping physical movements to VR changes
- ☐ Managing multiple physical objects

# Back to Proxies and Those Juicy Problems!



- ❑ Interesting to think about *which* world is easier/better to manipulate
  - Virtual World?
    - Better control
  - Physical World?
    - Higher haptic fidelity
    - Are we really limited to *everyday* objects?

# Matching Physical Shapes to VR Shapes



- ☐ How much difference can we get away with?
- ☐ Can we re-shape physical objects in simple ways (lengthen/shorten, widen)?

# Creating Contextual Representations



- How can we generalise things so that contexts can be shared across experiences?

# Mapping Physical Movements to VR Changes



- ☐ Maybe we can use redirected motion?
- ☐ Focusing on a task might allow us to trick the user into not noticing large changes?

# Managing multiple physical objects



- ❑ We've seen some cool redirection to a single physical proxy using distraction [Luv Kohli's work]
- ❑ Can we move physical object around instead of/in addition to redirection?
  - Robot arm?
  - Magnets?
  - Others?

# More Generally



- ❑ Virtual objects have properties
  - Colour, texture, size, position, etc.
  - We have ways of managing these (e.g., scene graphs)
- ❑ How do we remember proxy mappings across applications?
- ❑ How do we catalogue/share mappings with each other?
- ❑ Can the mappings be many-to-one, one-to-many?
- ❑ How do we manage the changing of mappings over time/user/context?

# Summary



- ☐ There is lots of cool stuff left to try in order to support users using haptics
- ☐ It's an engineering problem
- ☐ It's a human-physiology problem
- ☐ It's a human-perception problem
- ☐ It's an interesting problem!

## Questions?

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