CPE/CSC 486: Human-Computer Interaction

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Course Overview

- Introduction
- Cognitive Foundations
- Input-Output Devices
- Interaction Spaces
- Interaction Styles
- Interaction with Mobile Devices
- Speech-Based Interaction
- User Assistance
- Natural User Interfaces
- Case Studies
- Project Presentations

Logistics

- **Term Project**
  - opening ceremony ("ribbon cutting") on Thu, May 31, 9:30 - 11:00
    - guests
    - student presentations
- **Research Activity**
  - status update
  - final version due on Thu, May 24
    - presentations in class/lab
    - include your experiences with blog, video, etc. as medium

Chapter Overview
Natural User Interfaces

- **Motivation**
- **Objectives**
- **Terminology**
  - NUI
- **Background**
  - CLI => GUI => NUI
  - skills
  - cognitive load
- **Natural Interaction Guidelines**
  - enable instant expertise
  - reduce cognitive load
  - induce progressive learning
  - utilize direct interaction
- **Natural Interaction Application**
  - reuse innate abilities
  - reuse basic skills
  - acquire new skills
  - learn tasks
- **Important Concepts and Terms**
- **Chapter Summary**

Motivation

Objectives

Terminology

Natural User Interface
Natural Interaction

Natural User Interface

- **"A natural user interface is a user interface designed to use natural human behaviors for interacting directly with content."**
  - Blake, J. (2011). NUIs reuse existing skills (updated NUI definition) http://nui.joshland.org/2010/04/nuis-reuse-existing-skills.html
  - Blake, J. (2011). Natural user interfaces in .NET: WPF 4, Surface 2, and Kinect. Greenwich, Conn.; London: Manning; Pearson Education [distributor]. Retrieved from http://manning.com/blake/

NUI Aspects

- **interaction design**
  - NUIs should be natural for the user, not the developer
  - requires design and planning
  - appropriate for
    - user
    - content
    - context
- **skill re-use**
  - builds upon experience and expertise
  - often unrelated to computer use
- **direct interaction with content**
  - direct manipulation where possible
  - controls only when necessary

Natural Interaction

- **interaction methods the user is familiar and comfortable with**
  - touch
  - gestures
  - speech
- **often built on metaphors drawn from real-world experiences**
- **emphasis on interaction style**
  - not so much on input modality
    - e.g. touch vs. keyboard/mouse

Natural Interaction Examples

touch-based

pinch, scroll, rotate, ...

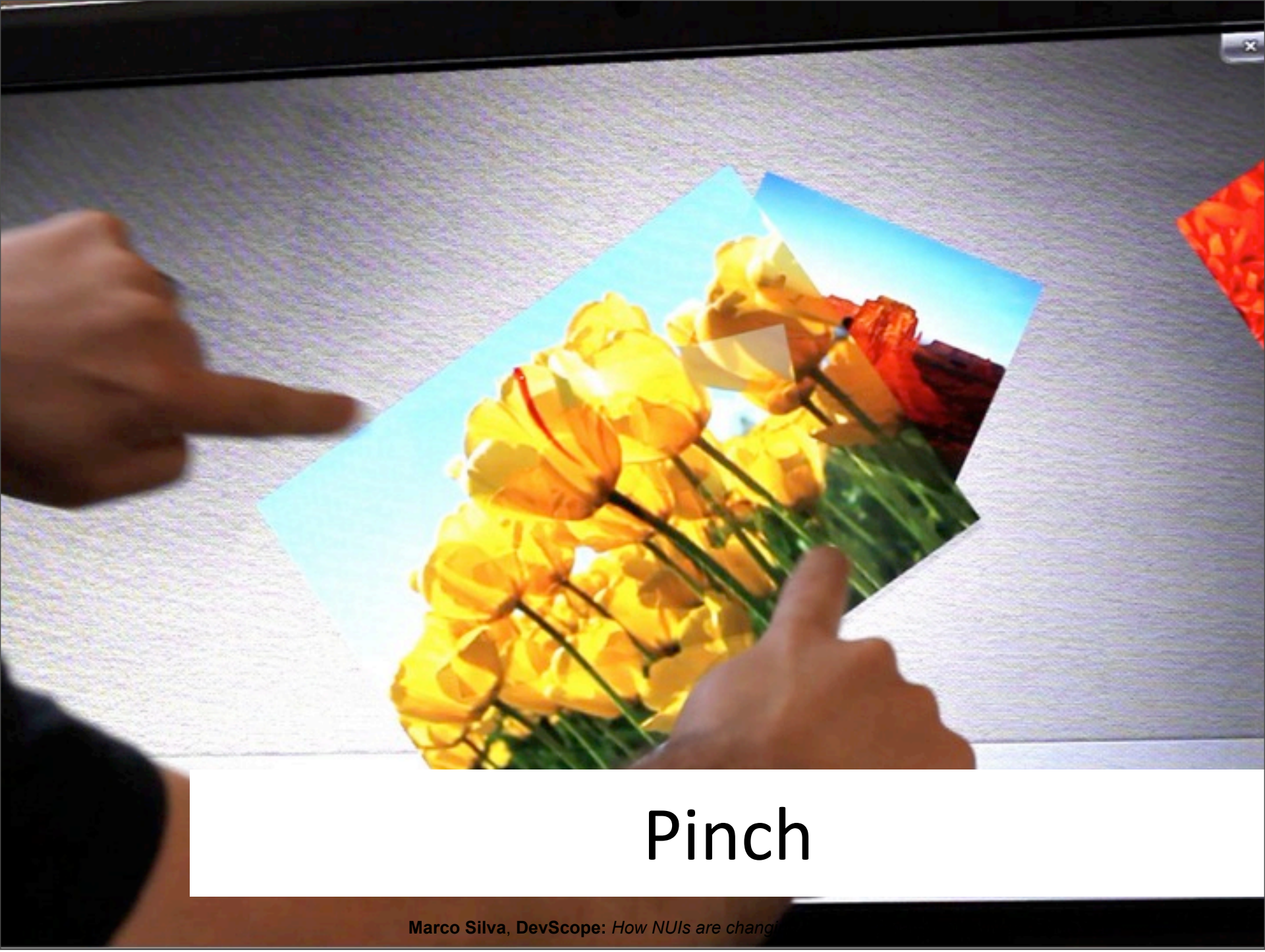
gesture-based

Kinect, Wiimote

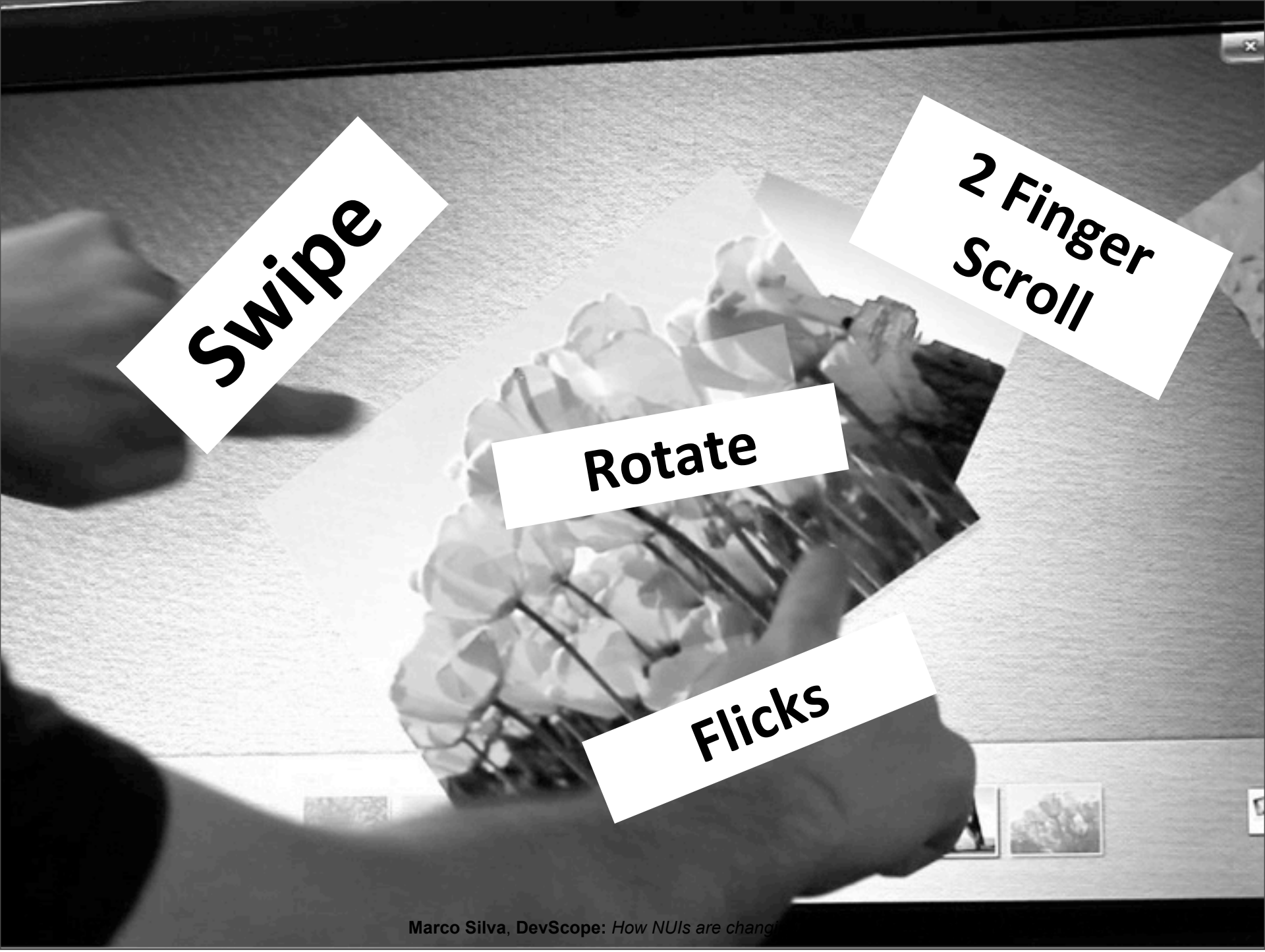
voice

Siri

augmented and virtual reality



Pinch



Marco Silva, **DevScope:** *How NUIs are chang*

Background

CLI => GUI => NUI
Direct Manipulation
Skills
Cognitive Load

CLI => GUI => NUI

- **evolution of user interfaces**
  - Command Line Interface
  - Graphical User Interface
  - Natural User Interface

http://www.flickr.com/photos/roguemm/2890425768/sizes/o/in/photostream/

CLI

COMMAND LINE INTERFACE

- STATIC
- DISCONNECTED (ABSTRACT)
- HIGH - LOW
- DIRECTED
- RECALL

GUI

GRAPHICAL USER INTERFACE

- RESPONSIVE
- INDIRECT
- DOUBLE MEDIUM
- EXPLORATORY
- RECOGNITION

NUI

NATURAL USER INTERFACE

- EVOCATIVE
- UNMEDIATED (DIRECT)
- FAST FEW
- CONTEXTUAL
- INTUITION

OUI

ORGANIC USER INTERFACE

- FLUID
- EXTENSIVE
- CONSTANT ZERO
- ANTICIPATORY
- SYNTHESIS

INTERFACES TYPES & THEIR CHARACTERISTICS
~ DENNIS WIXON

http://www.flickr.com/photos/rhinman/; http://farm4.staticflickr.com/3284/2799639297_3e967e6d79_o.jpg

Direct Manipulation

- **Benefits of direct manipulation interfaces**
  - Novices can learn basic functionality quickly, usually through a demonstration by a more experienced user.
  - Experts can work extremely rapidly to carry out a wide range of tasks, even defining new functions and features.
  - Knowledgeable intermittent users can retain operational concepts.
  - Error messages are rarely needed.
  - Users can see immediately if their actions are furthering their goals, and if not, they can simply change the direction of their activity.
  - Users have reduced anxiety because the system is comprehensible and because actions are so easily reversible.

Direct Manipulation in Context

- **the benefits from the previous slide apply nicely to NUIs**
- **they were formulated in the 1980s by Ben Shneiderman**
  - characterization of graphical user interfaces for direct manipulation
    - Shneiderman, B. (1984). The future of interactive systems and the emergence of direct manipulation. Proc. of the NYU symposium on user interfaces on Human factors and interactive computer systems (pp. 1–28). Norwood, NJ, USA: Ablex Publishing Corp. Retrieved from http://dl.acm.org/citation.cfm?id=2092.2093

NUI vs. GUI

- **NUI advantages**
  - better capabilities
    - new technologies
      - touch, gestures, speech
  - easier to learn
    - based on existing skills, experience, expertise
    - focus on natural behaviors
  - easier to use
    - direct manipulation taken further
    - real-world metaphors
- **GUI advantages**
  - text input
  - precise manipulation

Skills

- **simple skills**
  - learned skills that depend mostly on innate abilities
  - easy to learn
  - low cognitive load
  - easy to re-use and adapt
  - examples
    - pointing, grasping, tapping,
- **composite skills**
  - learned skills that depend on other simple or composite skills
  - take more effort to learn
  - higher cognitive load
  - often require conscious effort and practice
  - often used for more advanced tasks

Examples Composite Skills

- **object manipulation via mouse**
  - conversion of mouse movements into pointer movements
  - mapping of mouse actions to object manipulation actions
    - click and hold to drag
    - double-click, control-click, etc.
- **scrolling to view hidden screen content**
  - user must be aware that there is more content than can be seen
  - translation of user actions into scrolling actions
    - scrolling via touchpad vs. scrolling via scroll bar
- **navigation of folders**
  - terminology confusion: document, file, folder, directory, file system
  - hierarchical structure
  - multiple display options: icons, list, indented list, multiple panes, tree

Cognitive Load

- **measure of the working memory required to perform a task**
  - working memory capacity is limited
- **skills and cognitive load**
  - using skills increases cognitive load
  - composite skills have higher cognitive load

Cognitive Load Types

- **intrinsic**
  - inherent difficulty of the task or subject matter
  - difficult or impossible to change
- **extraneous**
  - cognitive load imposed by the interaction method
    - adjusting loudness in a car radio
      - knob
      - touch panel
  - should be minimized
- **germane**
  - involved in processing and understanding the task or subject matter
  - can be reduced by good interaction design

Cognitive Load Types and HCI

Cognitive load type	HCI description	Example
Intrinsic	The inherent difficulty of the task.	Interaction design cannot change the difficulty, but difficult tasks can be split into sub-tasks.
Extraneous	The load created by the skills used in the interaction.	A poorly designed interaction can make the user think more than necessary while a well-designed interaction can seem completely natural.
Germane	The load involved in learning the interface.	Well-designed interfaces focus on progressively teaching the user how to use it.

Natural Interaction Guidelines

enable instant expertise
reduce cognitive load
induce progressive learning
utilize direct interaction

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Instant Expertise

- **Reuse Skills**
  - common human skills
    - simple
    - composite
    - often based on
      - objects
      - containers
      - gestures
      - manipulations
  - skills based on task or domain expertise
    - users know how to do certain things
    - not all users may have the same set of skills
    - some skills may be obsolete or counterproductive
      - new tool requires different methods, workflow
    - most of theses skills are composite skills

Cognitive Load

- **design the most common interactions to use innate abilities and simple skills**
  - low cognitive load
  - easy to learn
  - may conflict with the reuse of "instant expertise" skills
    - e.g. touch-based interaction vs. re-use of mouse skills

Progressive Learning

- **if reuse doesn't work, teach simple skills**
  - easier to learn than composite skills
  - enables progressive learning
  - advanced tasks should be broken down into subtasks that use simple skills
- **present novice users with basic tasks first**
  - examine paths for common usage scenarios that lead from basic tasks to complex tasks
  - reduce the number of options exposed to the user
    - advanced options should be available to experienced users
      - may be more difficult to access

Direct Interaction

- **direct**
  - identification of the object to interact with
- **works well with touch and gesture-based methods**
  - touch or apply gesture to an object visible on the screen
- **more difficult with voice, virtual reality**
  - identification of objects through speech can become complicated
    - "the green square in the upper left corner of the screen"
  - lack of haptic feedback for VR

Directness Types

- **spatial proximity**
  - user action is close to the object
  - may be simulated via avatars
    - e.g. in virtual reality settings, 3-D
- **temporal proximity**
  - user action and interface re-action are (close to) simultaneous
- **parallel action**
  - user action and interface reaction overlap in at least one degree of freedom
  - most often: object moves in the same direction as the user's action

Case Study: Direct Interaction with Tetris

- **basic operations**
  - select object
    - default
  - move left, move right
  - move up, move down
  - rotate left, rotate right
  - start
  - sound on/off
  - reset

Dedicated Tetris Devices

- **handheld toys specifically designed for Tetris**
  - Tetris Jr. (key chain)
  - Radica Big Screen Tetris
  - Radica Tetris 360

http://theodor.lauppert.ws/games/s/images2/tetrisjr.png

Tetris Jr.

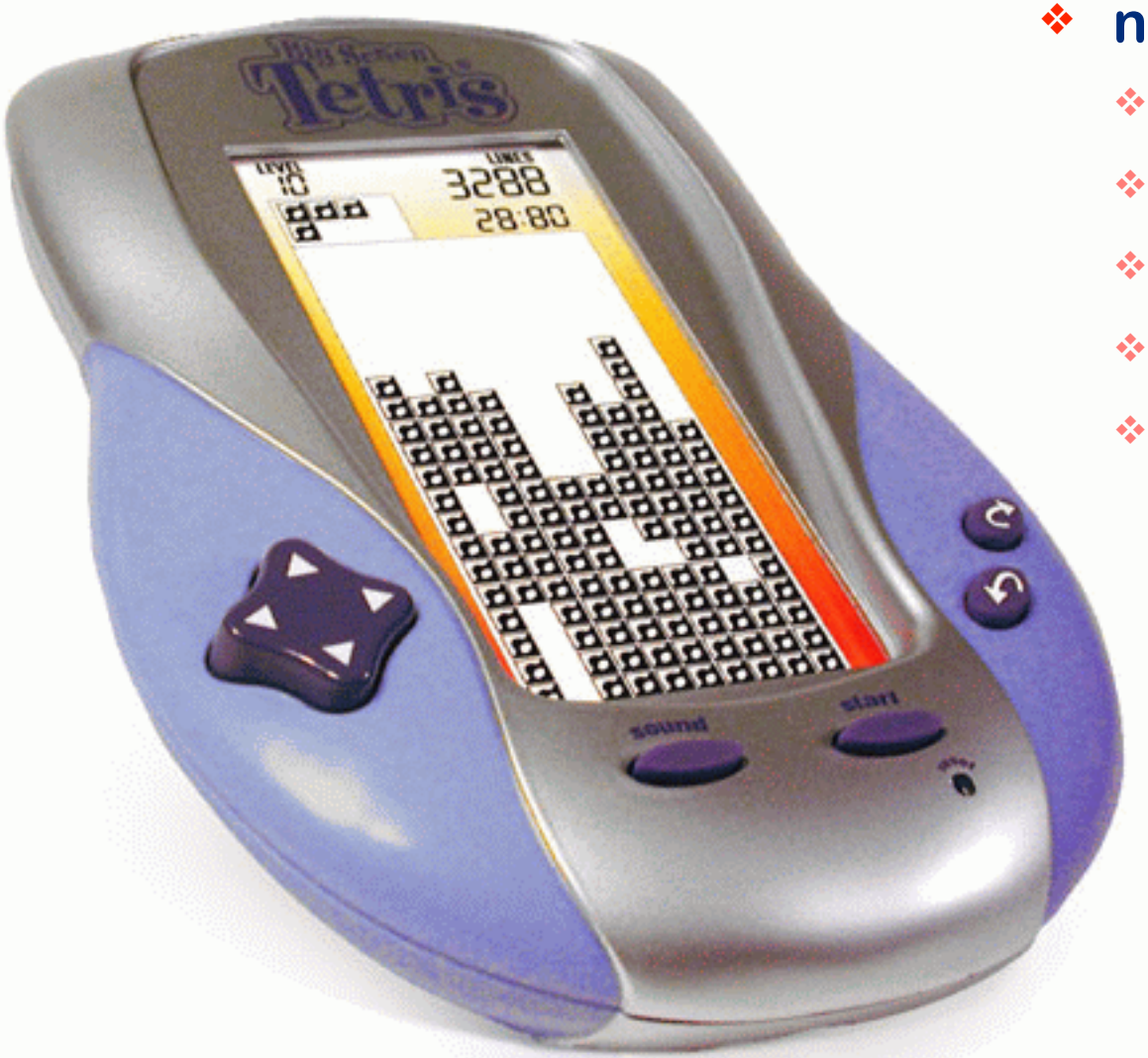
- **key chain device**
- **black and white display**
  - Tetris blocks
  - score
- **seven input buttons**
  - LEFT, RIGHT
  - ROTATE/START
  - MODE
  - ON/PAUSE
  - SOUND
  - RESET

http://www.strapya-world.com/images/medium/56/56-900105_MED.jpg

http://theodor.lauppert.ws/games/s/screen1/tetrisjr.gif

Radica Big Screen Tetris

- larger device
- B&W
- nine buttons
  - LEFT/RIGHT/UP/DOWN
  - ROTATE LEFT/RICHT
  - START
  - SOUND
  - RESET



http://static.productreview.com.au/pr.products/35851_big_screen_tetris.gif

http://spielzeug-express.de/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/i/m/image_2953.jpg

Radica Tetris 360

- Tetris variation
- eleven buttons

http://kidstoysheaven.com/img/mattel-radica-tetris-360_70967_250.jpg

Tetris on Game Stations

- **variations of Tetris have been implemented on many game stations**
- **straightforward mapping of operations to game station controllers**
  - directional pad (C-Up, C-Down, C-Left, C-Right)
  - Start
  - analog joy stick

Tetris on Computers

- **variations of Tetris are available for most consumer-oriented computer systems**
- **mapping of operations**
  - keyboard
    - cursor keys
    - other keys for remaining operations
  - mouse
    - move operations easy
    - rotate less obvious

Voice-Controlled Tetris

- **mapping of voice commands on equivalent key controls**
  - "press right arrow", ...
    - also shortcuts: "go right", "go left", ...
  - doesn't work with all implementations
    - Flash-based versions appear to be difficult
- **References**

  - Play Tetris with your voice. (n.d.). Retrieved May 29, 2012, from http://hand2mouth.wordpress.com/2009/09/03/play-tetris-with-your-voice/
  - Sporka, A. J., Kurniawan, S. H., Mahmud, M., & Slavík, P. (2006). Non-speech input and speech recognition for real-time control of computer games (p. 213). ACM Press. doi:10.1145/1168987.1169023
  - Yuan, X., & Fan, J. (2011). Design and implementation of voice controlled Tetris game based on Microsoft SDK. Multimedia Technology (ICMT), 2011 International Conference on (pp. 275 –278). doi: 10.1109/ICMT.2011.6001825

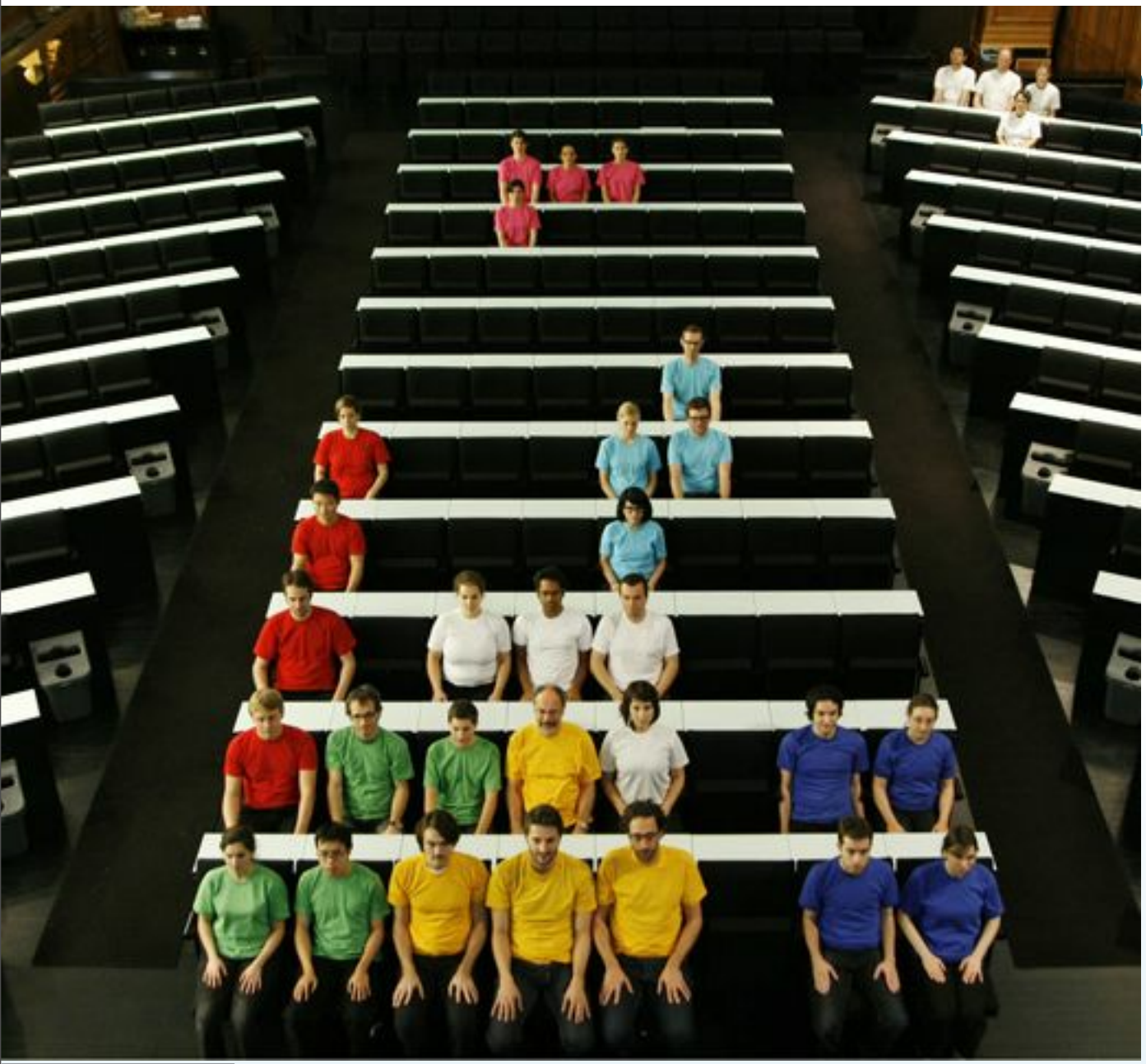
Touch-Based Tetris

- **many variations of Tetris on smartphones, tablets**
- **direct mapping of operations to touch-based gestures**
  - move => drag, swipe
  - rotate => semi-circular swipe
- **References**
  - Collberg, C., Kobourov, S., Kobes, S., Smith, B., Trush, S., & Yee, G. (2003). TetraTetris: A Study of Multi-User Touch-Based Interaction Using DiamondTouch. Human-computer interaction: INTERACT'03; IFIP TC13 International Conference on Human-Computer Interaction, 1st-5th September 2003, Zurich, Switzerland (p. 81).
  - Tetris, Touch API and Android. (n.d.).RIAgora. Retrieved May 29, 2012, from http://www.riagora.com/2010/05/tetris-touch-api-and-android/

Tetris and BCI

Human Tetris

- **performance by Guillaume Reymond**
  - http://www.youtube.com/watch?feature=player_detailpage&v=G0LtUX_6IXY
- **Tetris skaters**
  - http://www.youtube.com/watch?feature=player_detailpage&v=Fwvc6fmXmuY
- **game show patterned after Tetris**
  - a styrofoam wall consisting of Tetris blocks moves towards the contestants
  - contestants have to position themselves so that they can fit through the openings
  - otherwise they are pushed into a pool of water
- **also known as "Brain Wall" or "Hole in the Wall"**
  - comes in many different variation in many countries
- **References**
  - 36 Skaters Make Downhill Neon Video Game w/ Freebords. (2009). Retrieved from http://www.youtube.com/watch?v=Fwvc6fmXmuY&feature=youtube_gdata_player
  - It's People. Tetris is Made Out of People! · Technabob. (n.d.). Retrieved May 29, 2012, from http://technabob.com/blog/2007/12/31/its-people-tetris-is-made-out-of-people/
  - The Original Human TETRIS Performance by Guillaume Reymond. (2007). Retrieved from http://www.youtube.com/watch?v=G0LtUX_6IXY&feature=youtube_gdata_player



http://technabob.com/blog/wp-content/uploads/2007/12/human_tetris.jpg

Human Tetris 3

- **band from Moscow**
  - http://humantetris.bandcamp.com/
  - http://www.facebook.com/pages/Human-Tetris/132302626840565

http://humantetris.bandcamp.com/album/happy-way-in-the-maze-of-rebirth

Tetris and AR/VR

- **Tetris is used as experimental scenario for human-computer interaction in augmented and virtual reality systems**
  - several versions available or under development for MS Kinect
- **mapping of operations to actions**
  - move => grab & drag
  - rotate => grab & rotate
    - single-handed or two-handed

Tetris and AR/VR References

- Ha, T., & Woo, W. (2006). Bare Hand Interface for Interaction in the Video See-Through HMD Based Wearable AR Environment. In R. Harper, M. Rauterberg, & M. Combetto (Eds.), Entertainment Computing - ICEC 2006, Lecture Notes in Computer Science (Vol. 4161, pp. 354–357). Springer Berlin / Heidelberg. Retrieved from http://www.springerlink.com/content/r85485233j450661/abstract/
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- TechCrunch | Play Tetris Through The Kinect. (n.d.).TechCrunch. Retrieved May 29, 2012, from http://techcrunch.com/2011/07/05/play-tetris-through-the-kinect/

- **Tetris played with buildings**
  - Delft University
  - MIT

http://zapp5.staticworld.net/images/article/2012/04/tetris-11351126.jpg

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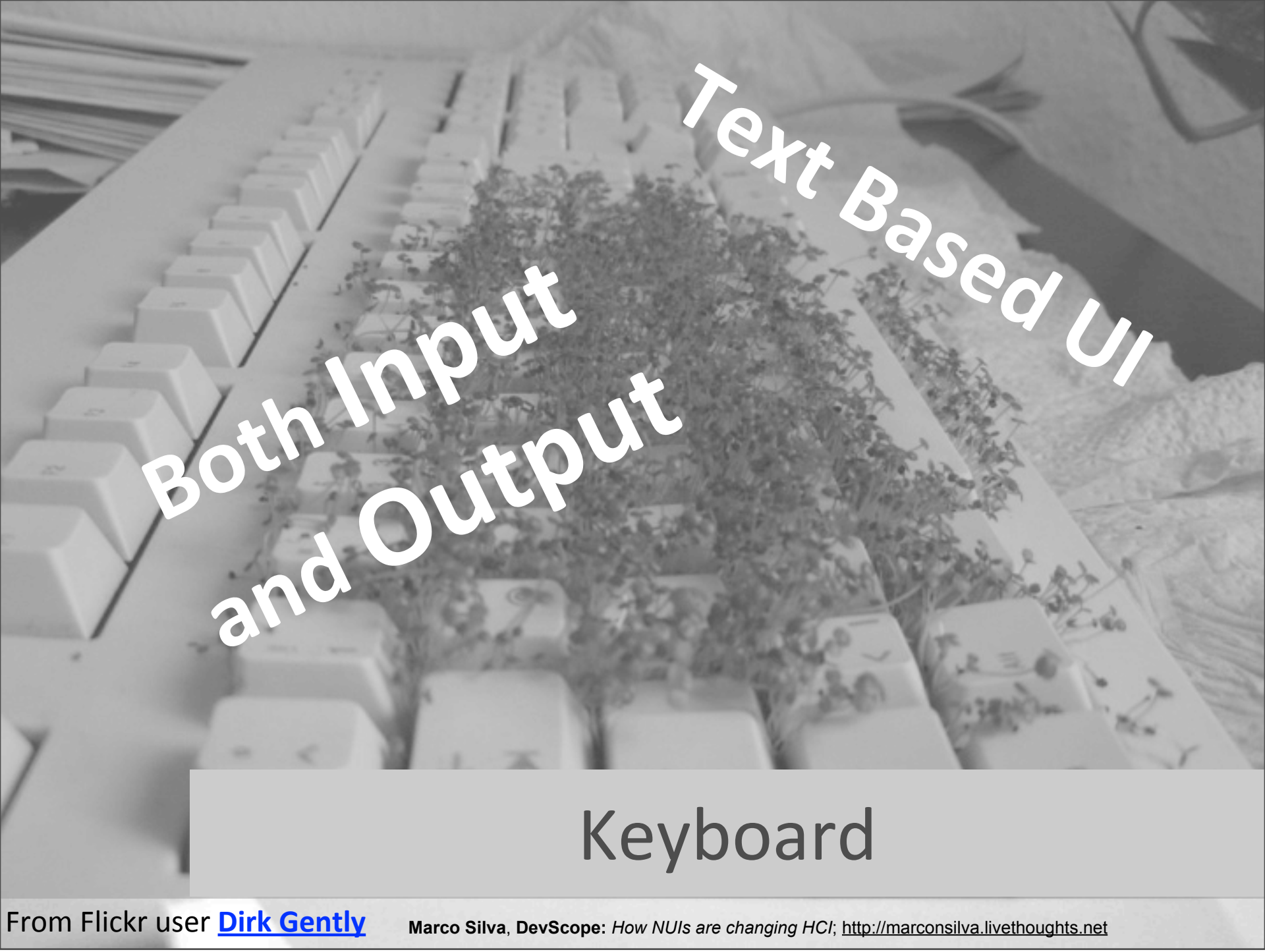
Real-World Tetris References

- MIT Students Hack Building, Play Tetris [VIDEO]. (n.d.).Mashable. Retrieved May 29, 2012, from http://mashable.com/2012/04/23/tetris-building/

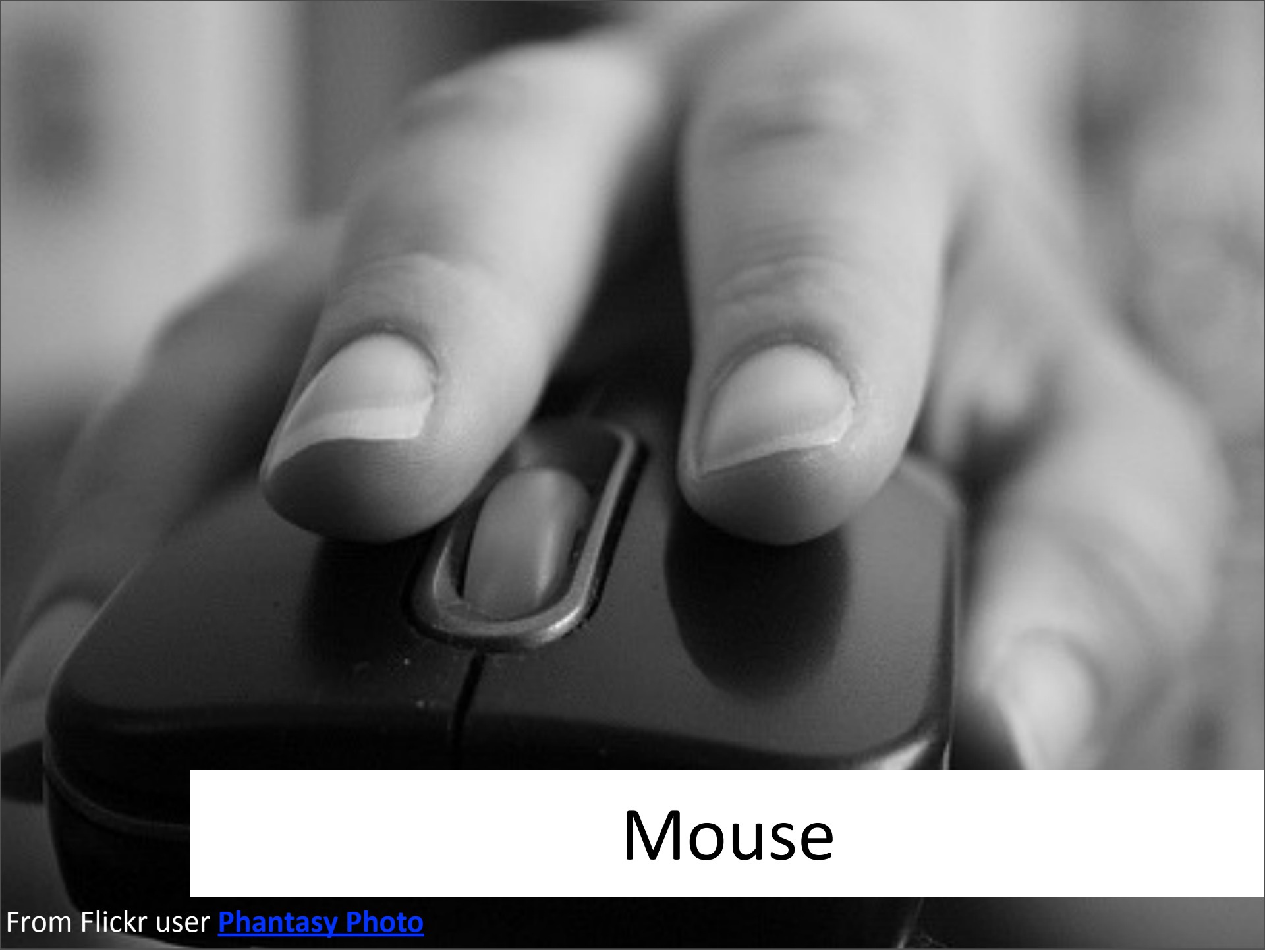
- Tetris for Buildings - November 1995 - Two Thousand Square Meter Of Tetris (23.94M). (2010). Retrieved from http://www.youtube.com/watch?v=LwNQqePk8Kg&feature=youtube_gdata_player

Keyboard

From Flickr user **Dirk Gently**

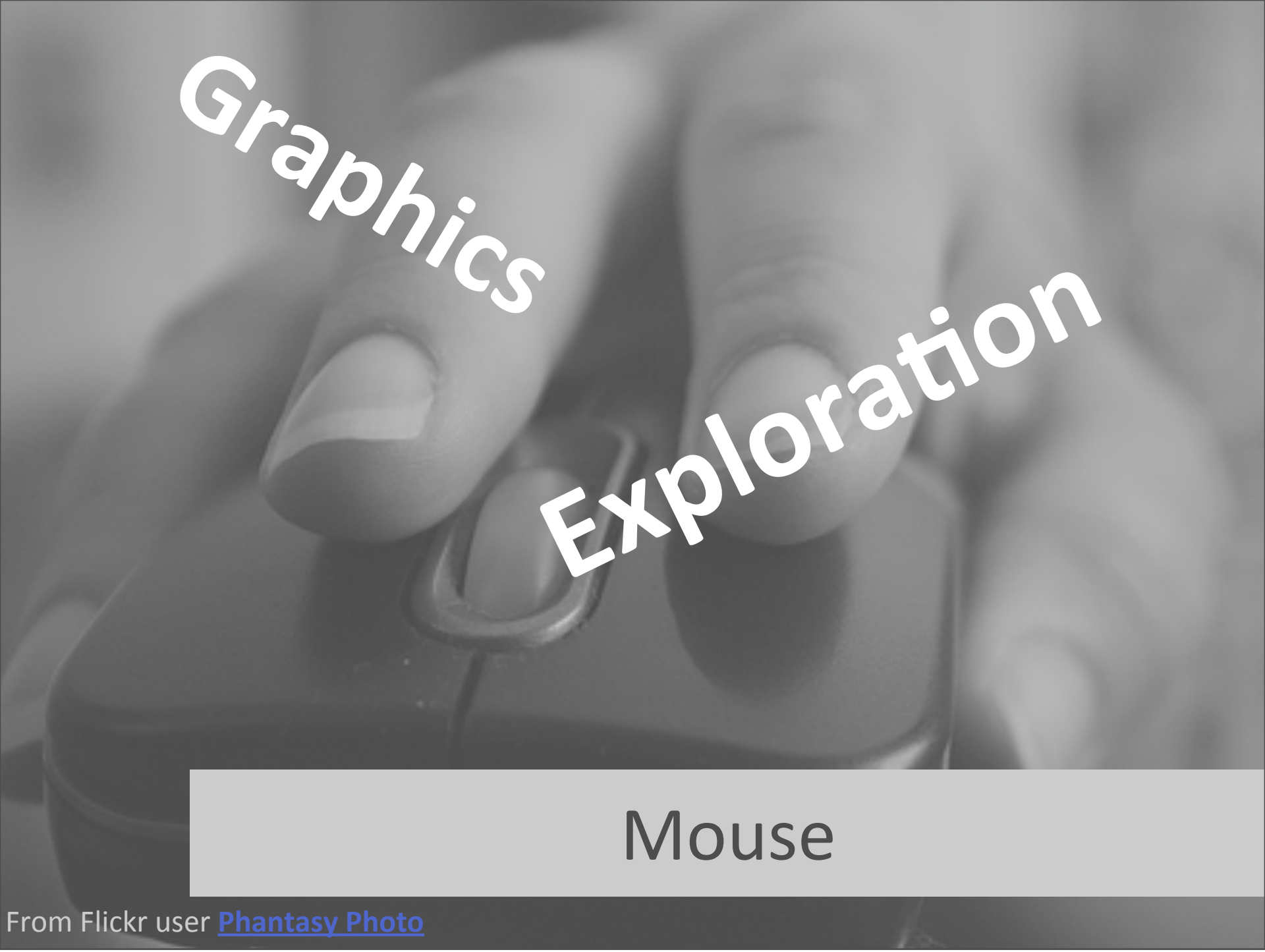


From Flickr user Dirk Gently



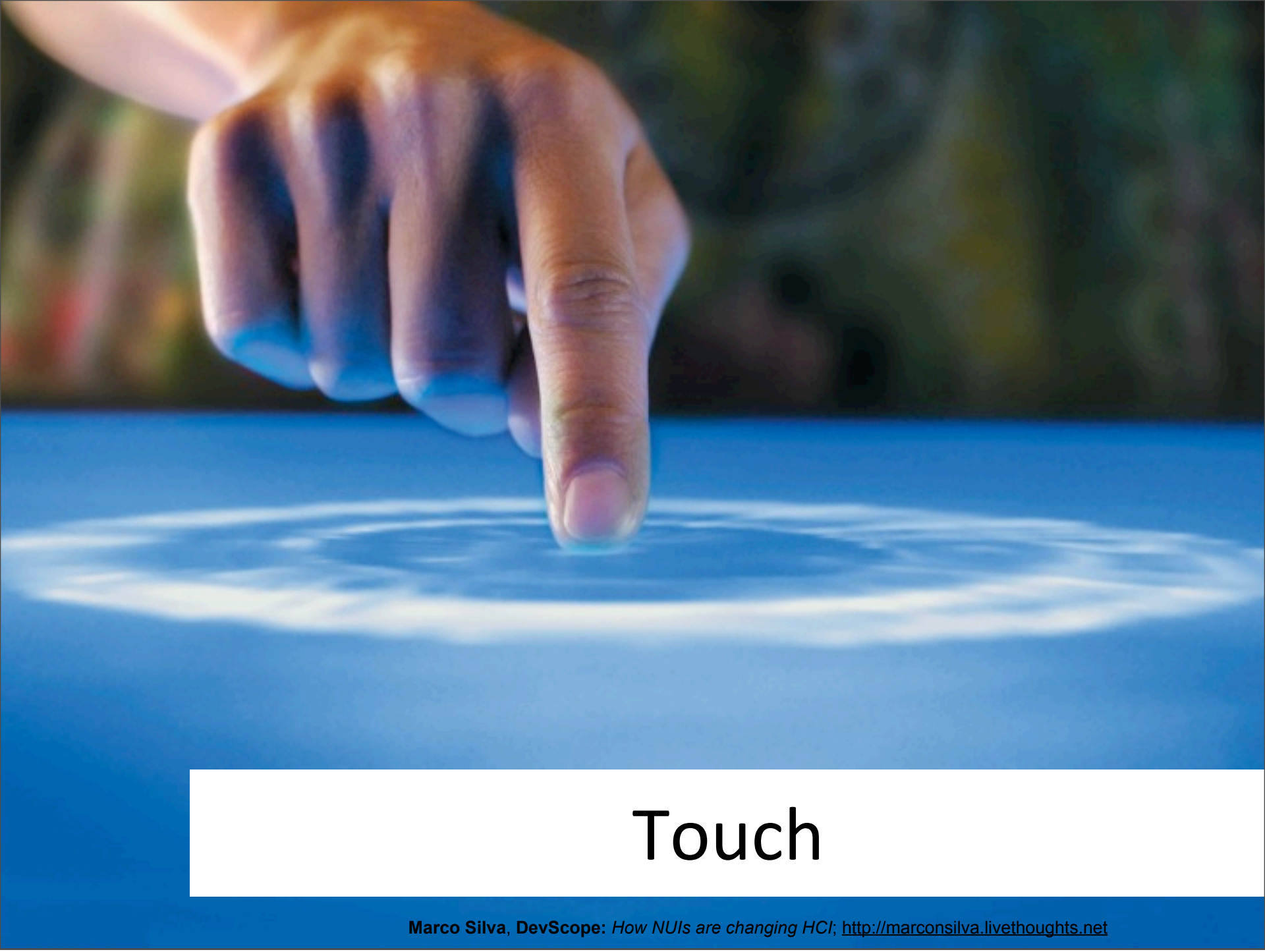
Mouse

From Flickr user [Phantasy Photo]



Mouse

From Flickr user Phantasy Photo



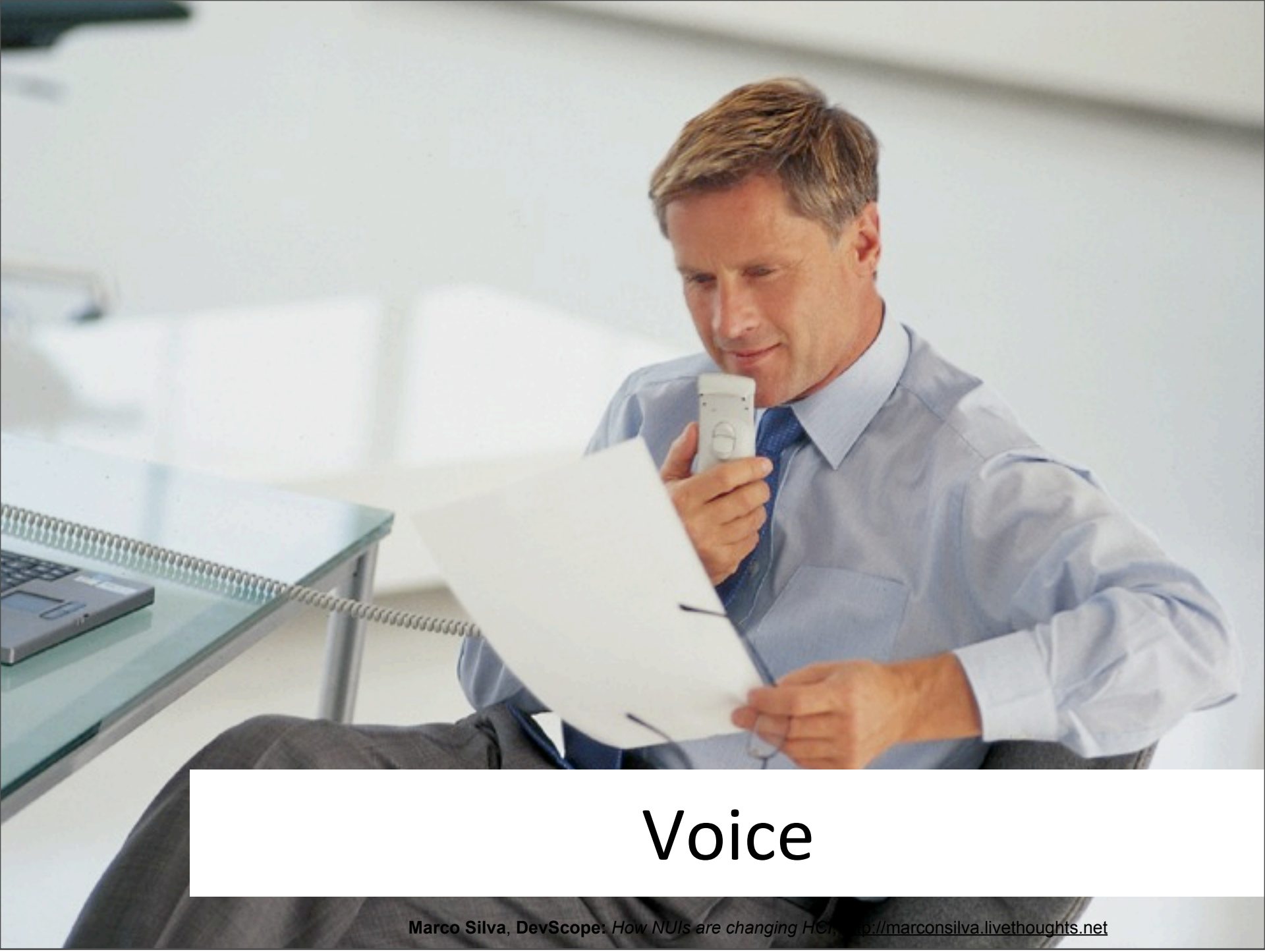
Touch

Gestures

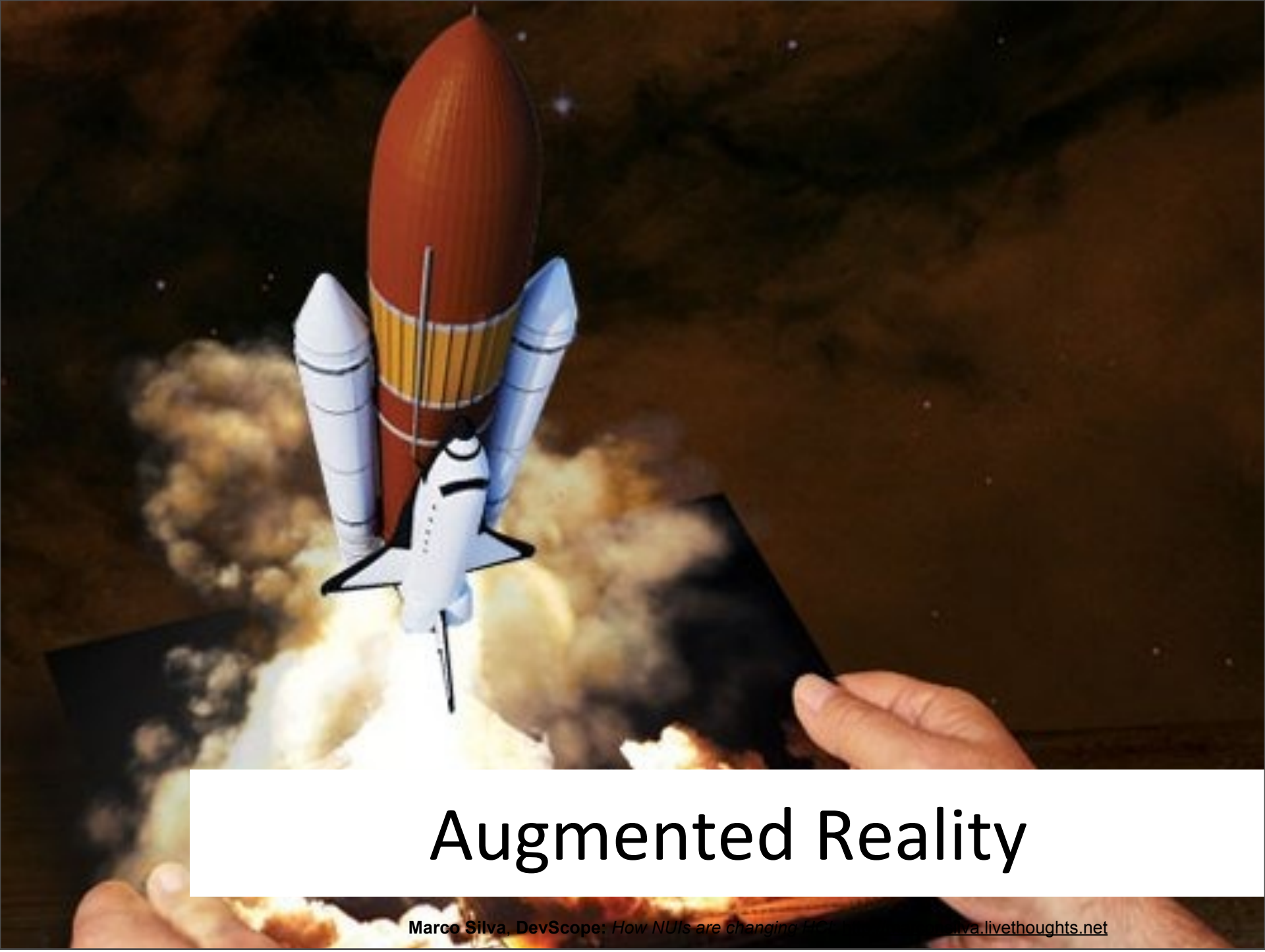
changing HCI; http://marconsilva.livethoughts.net

Touchless

Object Recognition



Voice



Augmented Reality

Marco Silva, **DevScope:** *How NUIs are changing* [illegible] va.livethoughts.net

Marco Silva, **DevScope:** *How NUIs are changing HCI*; http://marconsilva.livethoughts.net

Marco Silva, **DevScope:** *How NUIs are changing HCI*; http://marconsilva.livethoughts.net


vodafone
Hyves
facebook
Gowalla
foursquare


Marco Silva, **DevScope:** *How NUIs are changing HCI*; http://marconsilva.livethoughts.net


XBOX 360
Wii
SONY

Marco Silva, **DevScope:** *How NUIs are changing HCI*; http://marconsilva.livethoughts.net

Lionhead Studios “Milo”

Natural Interaction Application

reuse innate abilities
reuse basic skills
acquire new skills
learn tasks

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Reuse Innate Abilities

- **object permanence**
  - objects still exist even if they're not visible
    - important milestone in cognitive development of children
  - users expect objects to be in the location and condition they left them
    - applies to documents and other objects
  - example: file management
    - relies heavily on object permanence
    - requires composite skills
    - touch-based devices often hide file management
      - if necessary, handled by applications
  - content-centric interaction
    - emphasis on content objects, not applications
      - photos, text documents, email messages, ...

Reuse Basic Skills

- **containment relationship**
  - putting objects into other objects
  - very natural for some objects
    - very un-natural for others
  - example: categorizing items
    - categories are (virtual) containers
    - items with the same properties are moved into one container

Excursion: Categorization and Cognitive Load

- **Which of the following options for categorizing items have high or low cognitive loads, respectively?**
  - category list box, list of item with check boxes, apply button
  - list of items with drop down lists of categories per item
  - side-by-side lists with arrow buttons to move items
    - e.g., all items in a list on the left, specific category on the right
  - dragging items into containers that represent categories

Acquire New Skills

- **transfer of skills**
  - application of the pinch gesture to text
  - intended result is a change in font size
- **demonstration of skills**
  - explicit display of a skill to a novice user
  - disruptive for instructor and learner
- **social observation of skills**
  - casual observation of other users
    - no interruption of their activities
  - requires an opportunity to observe others

Learning Tasks

- **tasks that are enhanced specifically to teach a particular skill or interaction pattern**
  - often incorporates demonstration and practice activities

References

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  - Cognition & The Intrinsic User Experience (thejordanrules.posterous.com)
  - OUI Brave a NUI World (threeminds.organic.com)
  - Are We Moving Toward A More Natural Future With Technology? (InnovationToronto.com)
  - How Can Leap's New Motion Controller Top Kinect PCs? (rant4u.com)
  - Microsoft shows off NUI, Kinect-focused research projects (zdnet.com)

Important Concepts and Terms

Chapter Summary