UNIVERSITY OF CRETE
COMPUTER SCIENCE DEPARTMENT

COURSE CS-564 (OPTIONAL)
ADVANCED TOPICS
IN HUMAN – COMPUTER INTERACTION

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Public Displays and Large Screens

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- Public Displays
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Public Displays

Characteristics of Public Displays (1/2)

- Push-based distribution
  - Viewers do not need to make an active decision to access content on a typical digital sign. Rather, the content that is shown is often content that the users themselves would not actively seek out but that others wish them to see
    - Advertisements
    - Information dissemination
    - Emergency announcements
- Context-specific content
  - The fact that signs are physically embedded in the world means that the content they show can (and indeed should) be related to their physical context
  - In contrast to many other communication media, in which information is often presented out of context
    - Exception: World Wide Web advertising

Characteristics of Public Displays (2/2)

- Multimedia content
  - Unlike their traditional paper counterparts, digital signs can display a wide range of media types
    - Moving images
    - Interactive applications
    - Games
- Easy to update and efficient use of physical space
  - Remote updates
  - Frequent change of content for minimal cost
  - Efficient use of physical space
    - The above attributes enable digital sign screen real estate to be shared at a very fine temporal granularity, enabling more efficient use of the potentially very valuable physical space occupied by the display

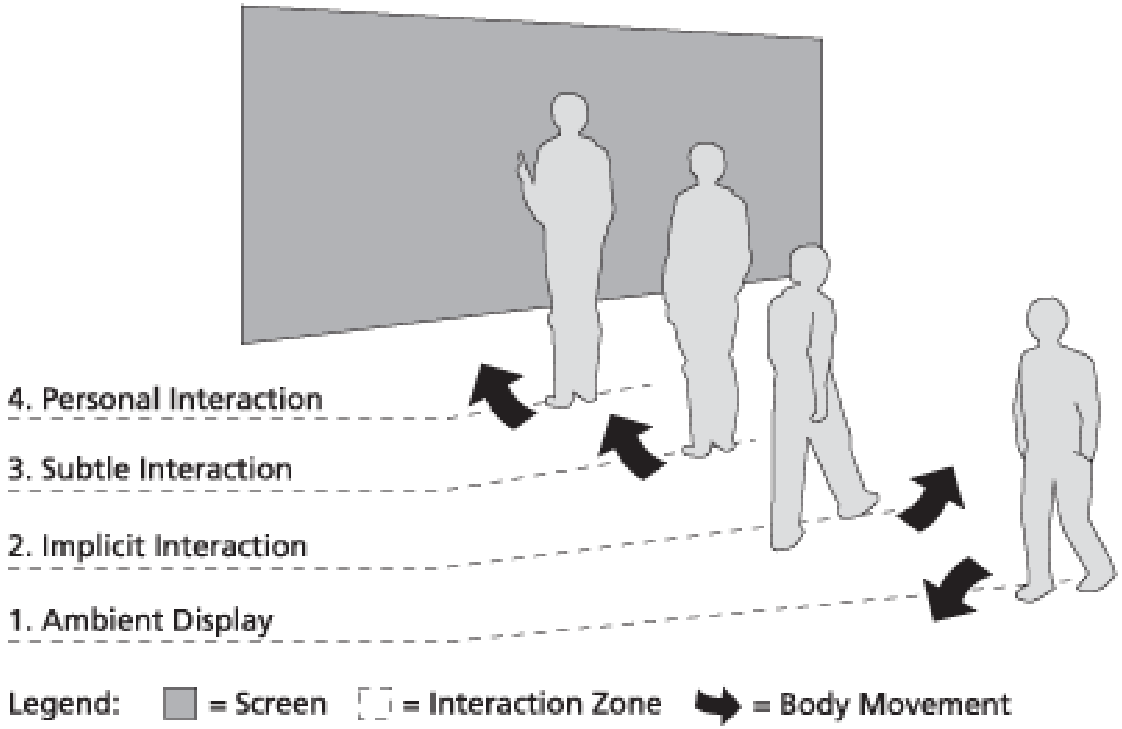
Advantages over Physical Signage

- Facilitating frequent, timely updates
- Increasing accuracy and provision of highly dynamic information, that would not otherwise have been made available
- Improving the aesthetics of a space (digital artwork, video, other media)
- Personalized interactive content has the potential to
  - Promote viewer engagement
  - Encourage social interaction with the space

Shortcomings of Digital Displays

- It is hard to understand how many people actually see digital displays
  - Difficulty to establish new business models
- There is no signage equivalent of a user “clicking through” on a piece of content
  - Makes encouraging and tracking user actions difficult
- Encouraging passersby to see and interact with content
  - Creation and distribution of engaging content is key to realizing the potential offered by the installation of digital displays in public spaces
- Public engagement with public displays is in general low
  - Viewers have become skilled at ignoring them (display blindness) [Müller et al., 2009]
  - Users look at displays in general for <2 seconds

Refined Spatial Model of Interaction (1/2)



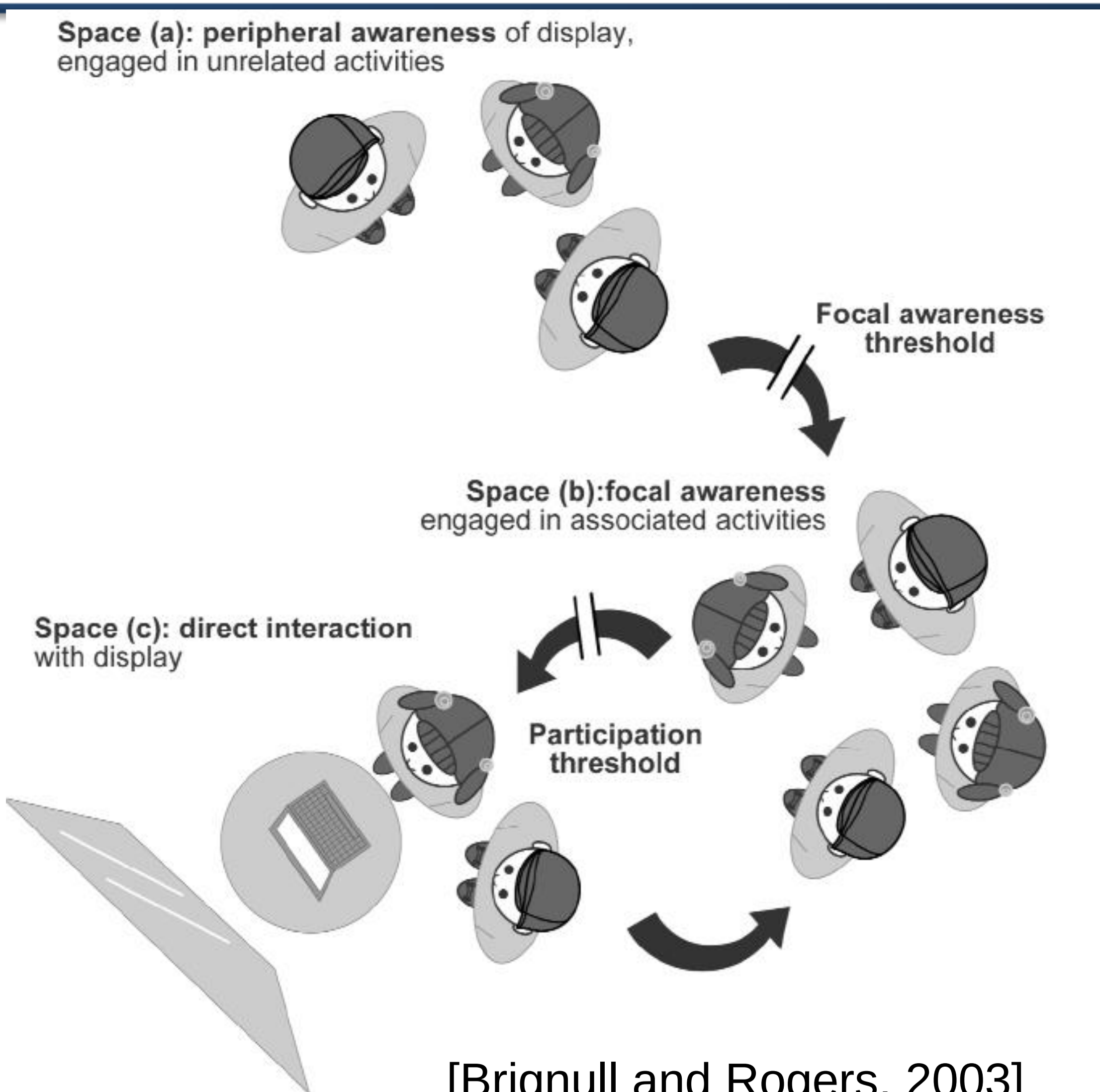
[Vogel & Balakrishnan, 2004]

- Dividing cell interaction zone into subtle and personal interaction zone
- Generalizing idea of a notification zone into an implicit interaction zone
- Relation to Hall's theory of proxemics
- Ambient Display Phase
  - Neutral state: ambient display as anchor point for subsequent interactions

Refined Spatial Model of Interaction (2/2)

- Implicit Interaction Phase
  - The system state shifts to an implicit interaction phase with peripheral notification when a user passes by
  - If they appear to be open to communication, the system should subtly react by showing an abstract representation of the user on screen
  - The user is notified in a subtle manner if there is an urgent personal or public information item that requires attention
- Subtle Interaction Phase
  - When the user approaches the display and provides an implicit cue such as pausing for a moment, the system should enter the subtle interaction phase
  - More detailed descriptions of the notifications and/or the current state of the available public information are displayed. The public information is also augmented with personal information relevant to the particular user and information context, if such information exists
- Personal Interaction Phase
  - After an information item is selected, the user should be able to move closer to the screen and touch information items for more details, including personal information
  - This phase should support longer duration interaction, say 2–5 minutes, and should be designed such that the disruption to the rest of the display is minimized, allowing simultaneous use by multiple people

The Public Interaction Flow Model (1/2)



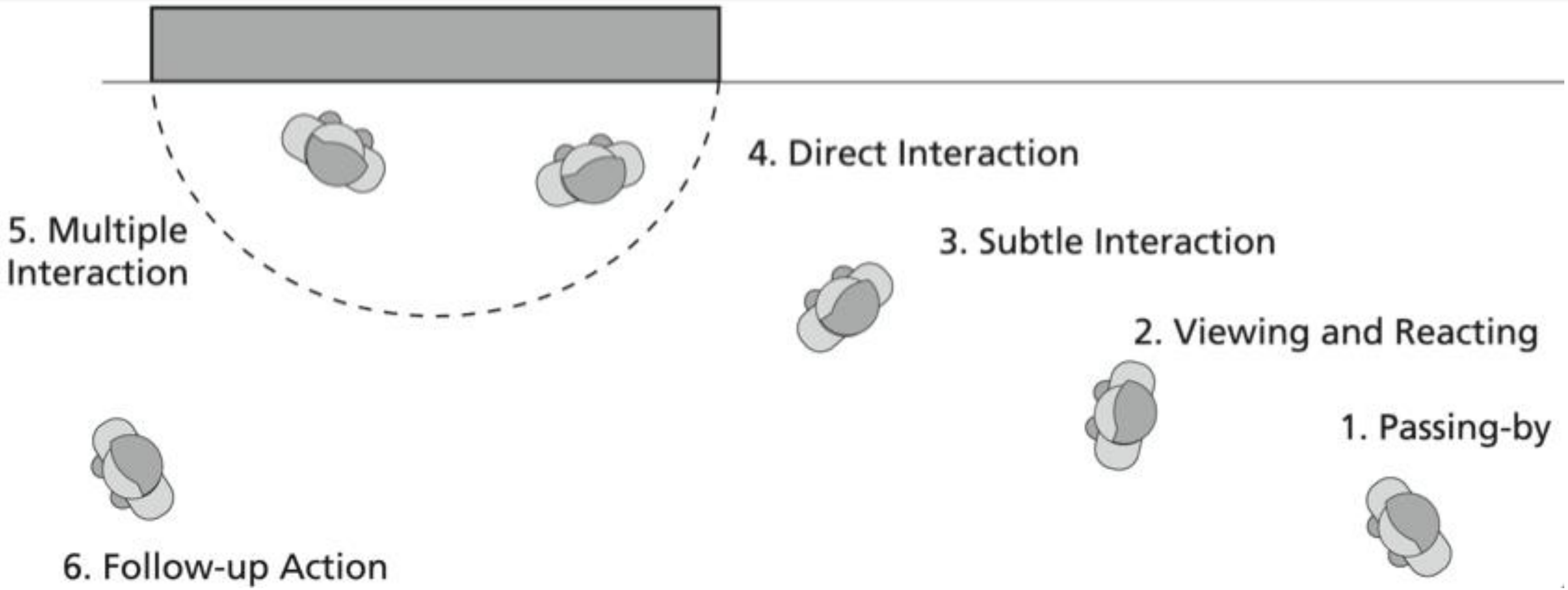
[Brignull and Rogers, 2003]

- Three activity spaces
  - Peripheral awareness activity: situations in which users are primarily socializing; aware of the presence of the display but not focused yet
  - Focal awareness activities: user attention shifts towards display (talking about content, watching the screen)
  - Direct interaction activities (explicit interaction with the content)

The Public Interaction Flow Model (2/2)

- Thresholds lead to people switching between activity spaces
- Strengths: supports multi-user interaction; takes people moving between activities into consideration
- Weakness: disregards implicit and explicit interaction from a distance

The Audience Funnel (1/2)



- Focuses on observable audience behavior
- Consists of several interaction phases
- Attempts to model the probability of users transitioning between phases (conversion rates)

[Michelis & Müller 2011]

The Audience Funnel (2/2)

- Passing By
  - Everyone who happens to be present in a certain vicinity of a public display can be called a passer-by
- Viewing & Reacting
  - As soon as a passer-by shows any observable reaction to the displays, such as looking at it, smiling or turning his head, he can be considered a viewer
- Subtle Interaction
  - As soon as the viewer shows any signs of movement that is intended to cause some reaction by the display, we can call him a subtle user
- Direct Interaction
  - After some initial subtle interactions users may try to position themselves in the center and become thus direct users]
- Multiple Interaction
  - Many users interacting with the display(s) after a phase of direct interaction (with one of the displays)

Interaction in Public Space

- The presentation of self
  - People want to maintain their role
  - Displays are a stage, design for introvert and extrovert people
- Control of access to self
  - People do not like to be unduly approached
- Data privacy
  - People do not like to be spied upon
- Public nature of space
  - You can not control the environment of the display
- Social behavior
  - People do not like to stand in the way of others

Calm vs. Engagement

- Calm Displays [Weiser and Brown, 1997]
  - Should slide effortlessly between center and periphery of attention
  - Should blend into the environment
  - Should be easy to ignore
- Engaging Displays [Rogers, 2006]
  - Should be fun to interact with
  - Should engage, inspire and entertain the audience
  - Should attract attention
- Displays may not be used at all if they fail to attract attention!

Tools vs. Toys

- Tools
  - Traditionally, public displays are viewed as tools
  - For tools, motivation for use is some external goal
  - The most important criteria for tools are usefulness and utility
  - What to optimize:
    - Time (Less is better)
    - Errors
- Toys
  - The most important criteria for toys are motivation.
  - What to optimize:
    - Conversion rates
    - Fun
    - Interaction times (More is better)
- It seems more appropriate to see public displays as toys rather than tools!

Understanding Attention

- Attracting attention is difficult (first click problem)
- Most displays receive little attention
- Naive approach: use stimuli to attract attention
  - Challenging in public space
  - Does not guarantee the user looks because many objects are competing for attention
- Another approach: use physical objects
  - Animatronic hands: physical attract loop shown to be twice as effective as a virtual attract loop
  - Drawback: less flexible, difficult to update with new content

Managing Attention

- Behavioral Urgency [Franconeri and Simons, 2003]
  - Attention is captured by stimuli that indicate the potential need for immediate action (e.g., an animal approaching)
  - Examples: abrupt appearance of new objects, luminance contrast changes, moving and looming stimuli
- Bayesian Surprise [Itti et al., 1998]
  - Bottom-up visual attention: measures the difference between posterior and prior beliefs about the world
  - Model predicts attention based on high entropy, contrast, novelty of motion

Managing Attention

- Honeypot Effect [Brignull and Rogers, 2003]
  - A crowd gathering around a display seems to attract further attention, drawing more people to the display
- Change Blindness
  - Effect that describes how to reduce the attention attracting effect of changes in display content (important when content should be changed with out the viewer noticing)
  - Examples: blanking an image, changing perspectives, displaying mud splashes, changing information slowly, changing information during eye blinks or saccades, changing information while occluded

Immediate Usability

- After people notice interactivity, immediate usability is important
- Recommendations [Kules et al., 2004]
  - Implement an attract sequence; clearly indicate how to end the attract sequence and begin using the system (e.g., call-to-action)
  - Support zero-trial learning: users should be able to user the interface after observing others or using it themselves for a brief period of time (15-60s)
  - Encourage users to immediately interact with the content
- Users not immediately being successful often simply abandon the device (already delay of a few seconds is problematic)
- Users think device is not interactive or broken

Motivating Further Engagement

- How to motivate people to interact?
  - People do not go out to look at a public display but tend to come across a public display (e.g., bus stop)
  - They become motivated by external factors to look
- Greater trend: spread of computer usage from the workplace into public life
  - Display to serve a range of functions (helping users achieve tasks to more speculative forms)
- Task-oriented theories: Regard the “how” of an interactivity, but not the “why”
- There is a significant need to advance understanding of the motivation behind users’ activities!

Potential Motivating Factors

- Challenge and Control
  - Can help to motivate users but must be carefully balanced
  - Too little challenge leads to boredom, too much challenge leads to anxiety
  - People strive for an optimal level of competency
- Curiosity and Exploration
  - Curiosity as a key characteristic of intrinsically motivating environments
  - Interaction should be neither too complex nor too trivial
  - Interactive elements should be novel and surprising but not incomprehensible
  - User should have initial expectations for how the interaction proceeds but these should only be partially met

Potential Motivating Factors

- Choice
  - Motivation for particular behavior increases if people can select between alternatives
- Fantasy and Metaphor
  - Imaginary settings appear to have a motivating effect, particularly if constraints of reality are switched off so that one imagines possessing new abilities
  - Extent to which interactive environments inspire fantasy determines their attractiveness and generates interest
- Collaboration
  - Interaction with other human beings
  - Ability to influence the interaction of another person is motivating

Large Screens

Overview

- Continued advances in display hardware, computing power, networking, and rendering algorithms have all converged to dramatically improve large high-resolution display capabilities
- Two common features of such displays are increased:
  - physical size
  - resolution
- In size, they range from:
  - small scale, expanding the conventional desktop
  - to much larger wall–size displays capable of presenting large amounts of information at a high level of detail

Advantages of Large Screen Displays (1/2)

- Expanding the conventional desktop leads to:
  - Greater satisfaction
  - Greater awareness and efficiency
    - spatial position of applications
    - bezel adaptation for task separation
    - awareness of secondary tasks
  - Decreased cognitive load
    - additional space for peripheral awareness (e.g., new e-mail arrival)
    - eliminate search tasks (e.g., ‘parking’ resources for future reference)
    - minimize task-switch and navigation
    - eliminate need for external aids (e.g., notepad)

Advantages of Large Screen Displays (2/2)

- Beyond the conventional desktop
  - Large displays can be used to gather several people around them and promote collaboration
  - Analysis work may benefit from a wider field of view (e.g., data overlaid on maps)
  - Greater pixel density may improve performance on spatial tasks (e.g., associate demographic statistics with the corresponding states)

Hardware Configurations (1/2)

- **CAVE and derivatives**
  - A CAVE is a small room or cubicle where at least three walls (and sometimes the floor and ceiling) act as giant monitors
- **Multi-monitor Desktop**
  - An increasingly popular configuration in businesses and homes to extend a standard desktop PC with more screen real estate
- **Tiled LCD Panels**
  - Sets of LCD displays arranged in a 2D array
    - like a **wall**, like a **table**, **curved**, or other configurations
  - **Advantages**
    - easier to align and color correct than projectors
    - less expensive than projectors
    - they take less space (no throw distance needed)
  - **Disadvantage**: the bezels between each tile

Hardware Configurations (2/2)

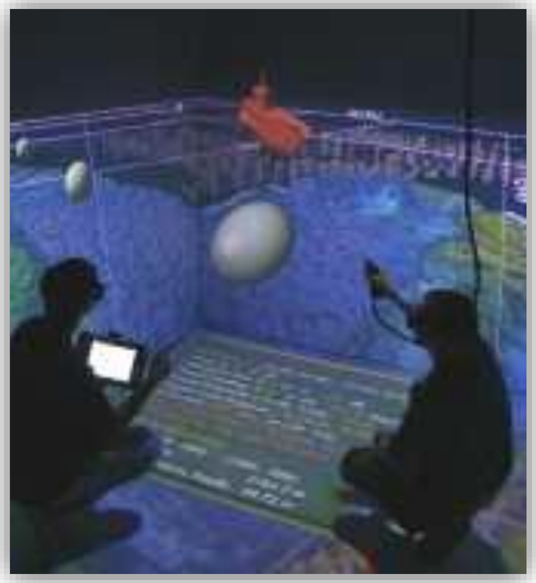
- **Projector Arrays**
  - Projector arrays can consist of CRT, light-valve, or LCD projectors
  - Projector arrays are becoming popular due to their lack of bezels and the constantly-improving seamless integration of multiple tiles
- **Stereoscopic Displays**
  - Two sets of pixels for an image, one set visible to the user's left eye and the other to the right eye
  - Special glasses or viewing aids are required to see the 3D effects
- **Volumetric Displays**
  - Rather than placing the pixels on a single surface, they “stack” Voxels (3D pixels) via different technologies to show depth

Surfaces

- Surfaces are digital displays allowing direct interaction through
  - Pen input
  - (multi)Touch input
  - 2D gesture recognition
- However, it is also possible to allow interaction well beyond the surface itself
- Several technologies permit interaction with surfaces from across room-size distances
  - **Sony Eyetoy** – uses computer vision to detect shape and movement
  - **Nintendo Wiimote** – uses computer vision and data from an accelerometer to gesture toward imagery
  - **Microsoft Kinect** – uses an infrared projector and an infrared camera to detect gestures and directions indicated by user movement

Applications of Large High-resolution Displays (1/5)

- **Command and Control**
  - military, aerospace, and telecommunications
- Example:
  - A submarine command application for detecting target submarines that operates in the immersive room
  - A sonar operator is immersed in an oceanographic view, where a set of tracking sonar buoys are dropped, and can visualize the output of several different tracking algorithms that have been developed



Applications of Large High-resolution Displays (2/5)

- **Vehicle Design**
  - displaying and interacting with vehicle models at **1:1 scale** is a fundamental requirement of the automotive design industry

- Automotive design studios have explored the use of a variety of large-format digital displays in their design workflow, including:
  A. tape drawing (a technique where black photographic tape is laid onto a drawing surface to create initial drawings of a car body)
  B. electronic drafting tables
  C. CAVEs
  D. PowerWalls

- They utilize such applications to:
  - evaluate human factors and ergonomics
  - analyze complex engineering data
  - build capabilities in vehicle manufacturing process development


B.


C.


D.

Applications of Large High-resolution Displays (3/5)

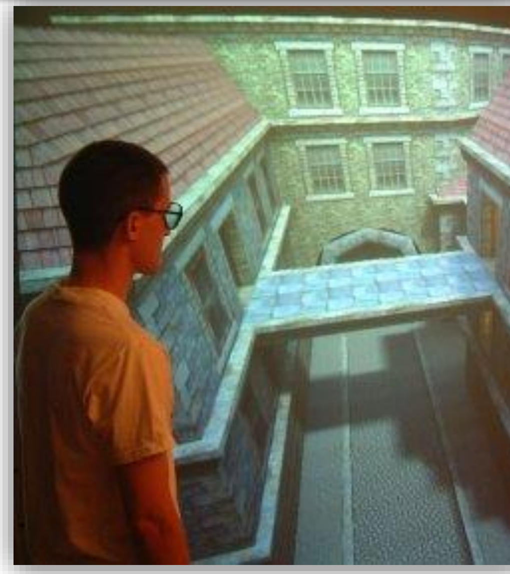
- **Geospatial Imagery and Video**
  - Large high-resolution displays offer the sense of scale needed for geospatial imaging and large film-quality video applications
  - The ability to obtain realistic terrain representations, zoom across scales, and create fly-through animations certainly benefits geospatial visualization
- Large displays allow users to see critical details in complex dynamic phenomena, such as subtle eddies that are critical to understanding global ocean circulation models
- High-resolution display systems are used by several major oil and gas companies for geospatial exploration and engineering, 3D mapping, and geophysical analysis

Applications of Large High-resolution Displays (4/5)

- **Scientific Visualization**
  - Viewing of data at true-to-life or human-scale physical sizes and
  - Viewing of large amounts of data simultaneously with the increased number of pixels available
- **Collaboration and Tele-immersion**
  - A public display surface may serve as a medium for presenting, capturing, and exchanging ideas
- **Education and Training**
  - Large high-resolution displays are a great tool for education and training in
    - astronomy, bioinformatics, medical imaging, urban planning, and geographic information

Applications of Large High-resolution Displays (5/5)

- **Immersive Applications**
  - that allow users
    to become immersed into a virtual world
- **Public Information Displays**
  - Where there once might have been a printed image or a low grade digital image, we are now starting to see large tiled public displays
  - Displays are not limited to flat billboards
  - Any surface or collection of surfaces has the potential to receive digital enhancement



Usability Issues and Interaction Challenges (1/4)

- Even for large displays that are still situated on physical desktops, the amount of screen real estate can make pointing to or even finding windows, icons, and menus difficult
- Many traditional user interfaces and interaction techniques become awkward or next to impossible to operate on large high-resolution displays
- Traditional desktop metaphors do not always scale well to large format displays
  - Windows
  - Icons
  - Menus
  - Pointing (WIMP)
- Researchers have been attempting to
  - modify or extend existing interface metaphors for large-format displays
  - create novel interaction techniques that scale well on large displays

Usability Issues and Interaction Challenges (2/4)

- **Reaching distant objects**
  - It is difficult for users to access objects scattered around on a wall-sized display, especially when they tend to stay relatively close to it
  - **Example:** if a user seated in front of a large screen tries to drag a file to the recycle bin near the lower right corner, it will be a terrible experience to use a traditional drag-and-drop interaction paradigm
- **Pointing and selecting**
  - Pointing is usually used for **interacting** with the system **or drawing the attention** of others
    - When using a touch display, an innocent indexical event can cause unintended system responses
  - But, when interacting with large displays…
    - … artifacts may be out of reach
    - … precision is compromised
    - … physical feedback is inexistent
  - **Example**: Imagine a 10-foot high, wall-sized display where no one can reach an artifact near the top of the screen

Usability Issues and Interaction Challenges (3/4)

- **Tracking the Cursor**
  - Increased physical screen size urged the users to employ higher mouse acceleration to traverse large displays
  - The faster the mouse cursor moves, the more difficulty users have keeping track of it
  - Locating a stationary cursor, becomes increasingly problematic on large displays
- **Crossing bezels**
  - Multi-monitors display bezels are beneficial in allowing users to organize multiple tasks onto different monitors
  - **Problems**
    - A window or an image may be sufficiently large to occupy several monitors, creating visual discontinuity at bezels
    - When a cursor traverses across a bezel, there is normally a discrepancy between its actual traveling course and what users may expect

Usability Issues and Interaction Challenges (4/4)

- **Managing space and layout**
  - Interaction with large high-resolution displays imposes many space and layout management issues, especially when windowing systems are used
- **Transitioning between interactions**
  - Interaction with large displays can be categorized into two broad paradigms:
    - Working up close to a large display - E.g. performing tasks involving dealing with detailed information
    - Performing tasks from a distance - E.g. sorting photos and pages or presenting large drawings to a group
  - **Necessity**: techniques allowing a smooth transition from up-close interaction to interaction at a distance and vice versa are needed

Interacting with Large Screen Displays (1/2)

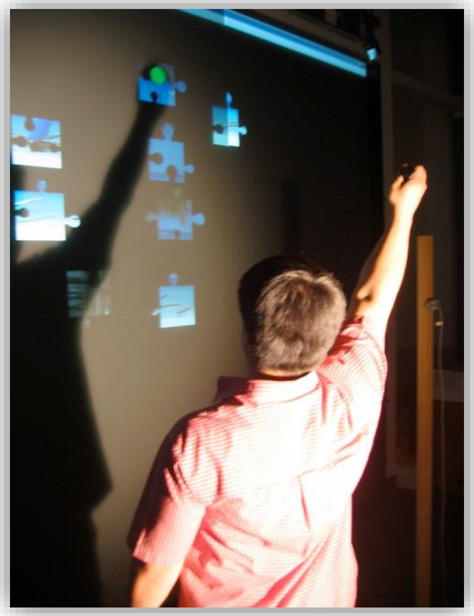
- Interaction *"On the surface"*
- Touch interactions directly on the reachable parts of the display
  - Using fingers, hands and tangible objects
  - For selecting, grabbing, throwing, rotating and moving
- **But**, when interacting with large displays …
  - … artifacts may be out of reach
  - … selecting items may require excessive movement
  - … while touching the screen, the whole screen is not visible to the user

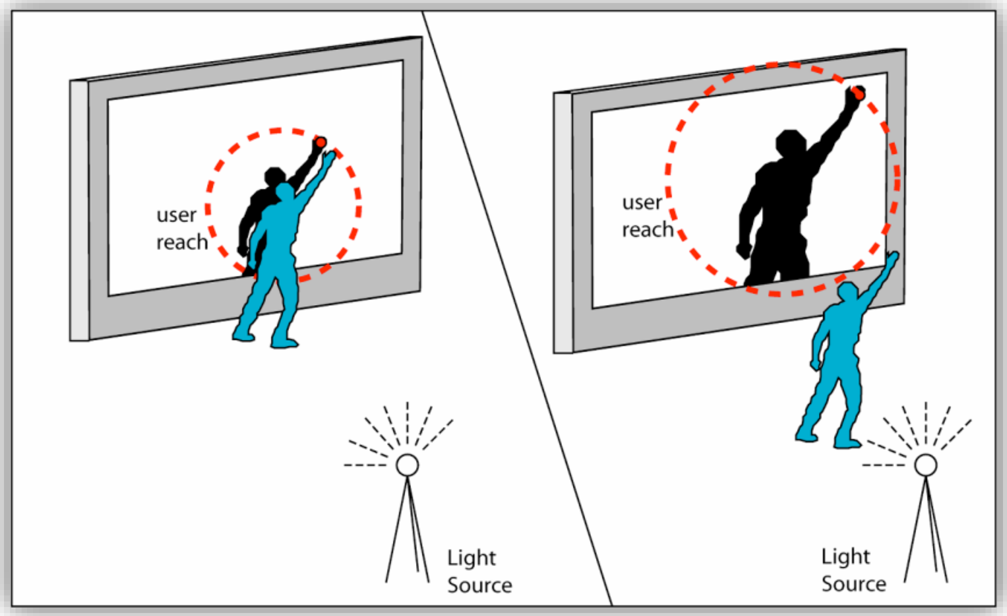
Interacting with Large Screen Displays (2/2)

- Interaction *"Above the surface"*
- Free-hand gesture recognition that occurs in the space above the screen
- These interactions typically:
  - point to, select and access content not reachable by the user's direct touch
  - map gestures to particular actions
- Best solution for **Public** displays …
  - It does not require to touch public installations which may be inappropriate for hygienic reasons
  - Users do not need to come close to the screen to interact
  - It can help noticing interactivity of public displays because passers-by can interact inadvertently
  - It may favor performative interaction (where an individual performs a given action with the awareness of others around them)

Interaction *"Above the surface"* (1/6)

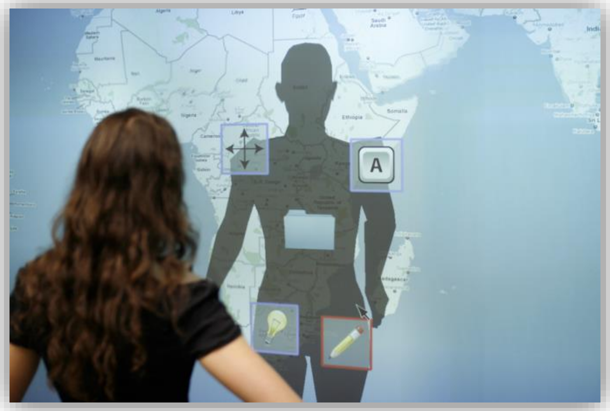
- Body-Centric Interaction
  - Shadow Reaching
    - The shadow follows the user's movements
    - The angle of the shadow can be adjusted to allow the user to interact with out-of reach objects





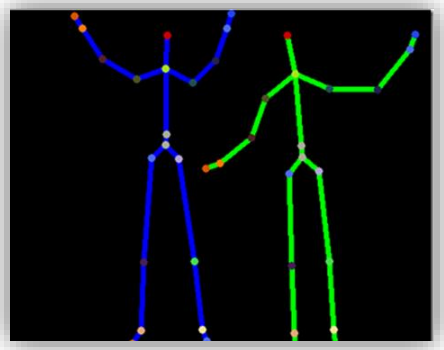
Interaction *"Above the surface"* (2/6)

- Body-Centric Interaction
  - Body-Based Tools
    - Virtual tools are stored at physical points on the user's body
    - To select a tool or enter a tool mode, the user points at a particular part of the body in order to make a selection
  - Body-Centric Data Storage
    - allows for convenient access to a user's personal data
    - each user's torso serves as a virtual container, from which personal data files can be accessed



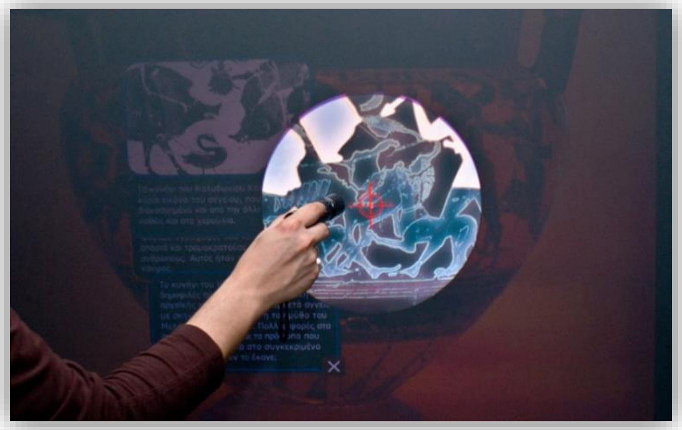
Interaction *"Above the surface"* (3/6)

- Detection of **gestures** and **directions** indicated by movement of the user's:
  - **Hands**
  - **Arms**
  - **Head**
  - **Legs**



Interaction *"Above the surface"* (4/6)

- Manipulating physical objects
  A. White paper tablets are used to display multimedia related to the selected city
  B. A flash light is used to display a modern rendition of an exhibit
  C. Fiducial markers are used to generate sound



B.

A.

C.

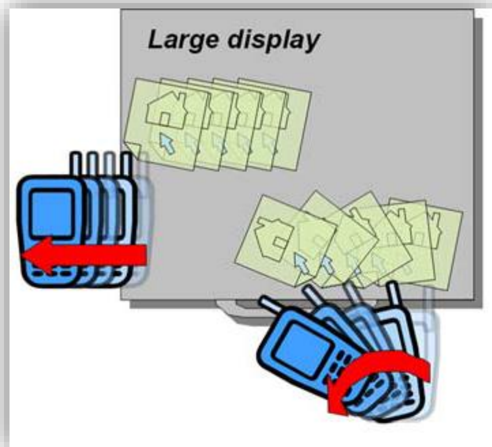
Interaction *"Above the surface"* (5/6)

- Interaction through mobile devices
  A. Duplicating the interface
  B. Migrating controls to the device screen
  C. Providing modified views of the visualized data (view ports)
  D. Using embedded sensors to interact

A. & B.

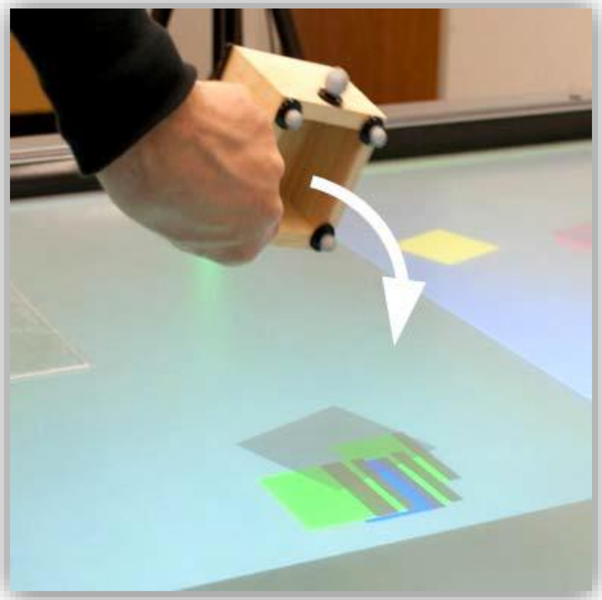
C.

D.



Interaction *"Above the surface"* (6/6)

- Interaction through smart objects
  - Using embedded sensors to interact



Text Input

- Physical keyboards are impractical
  - They take up too much space
  - They could occlude artifacts from view (if they were placed on top of a horizontal display)
- Alternative solutions
  A. Virtual keyboards on large interactive surfaces
  B. Virtual keyboards on mobile devices
  C. Invisible keyboards

A.

B.

C.

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The End

Questions?