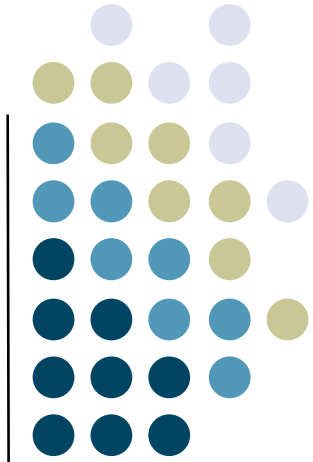
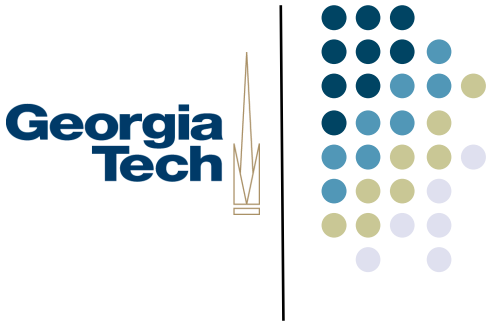
Sound and Non-Speech Interfaces: Going Beyond Conventional GUIs



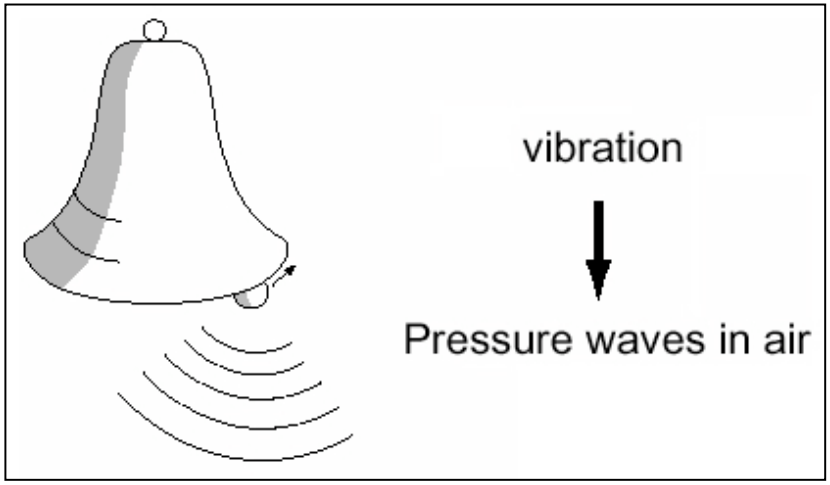
Georgia Tech

Audio Basics



How sound is created

- Sound is created when air is disturbed (usually by vibrating objects) causing ripples of varying air pressure propagated by the collision of air molecules

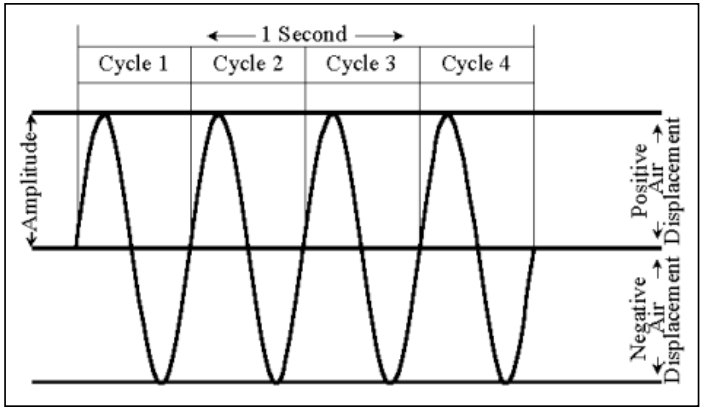


Why Use Audio?

- Good support for off-the-desktop interaction
  - Hands-free (potentially)
  - Display not necessary
  - Effective at a (short) distance
- Can add another information channel over visual presentation

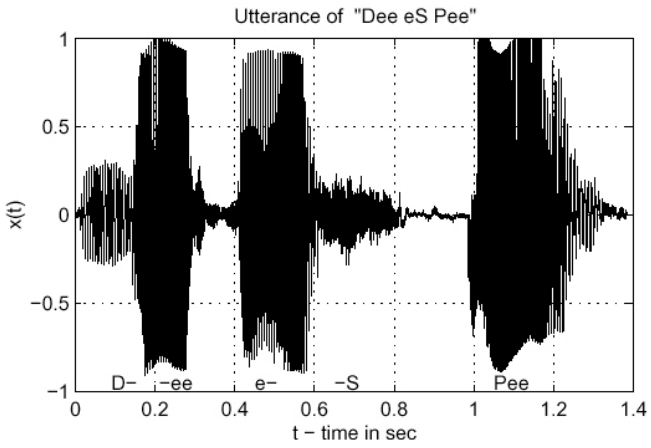
How Sound is Perceived

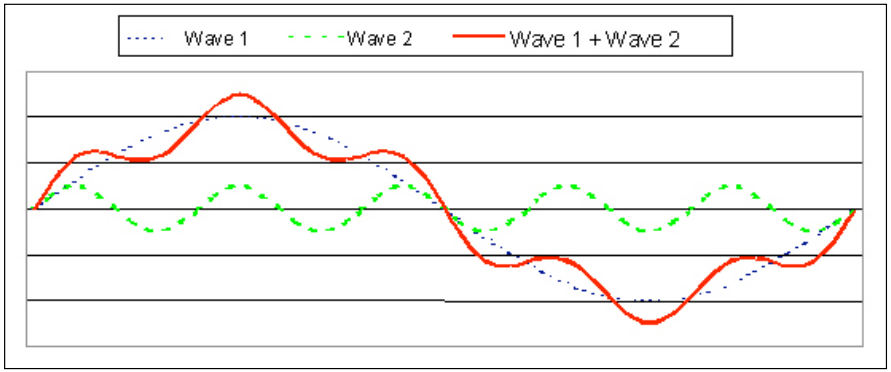
- Characteristics of physical phenomenon (the sound wave):
  - Amplitude
  - Frequency
- How we perceive those:
  - Volume
  - Pitch



Complex Sounds

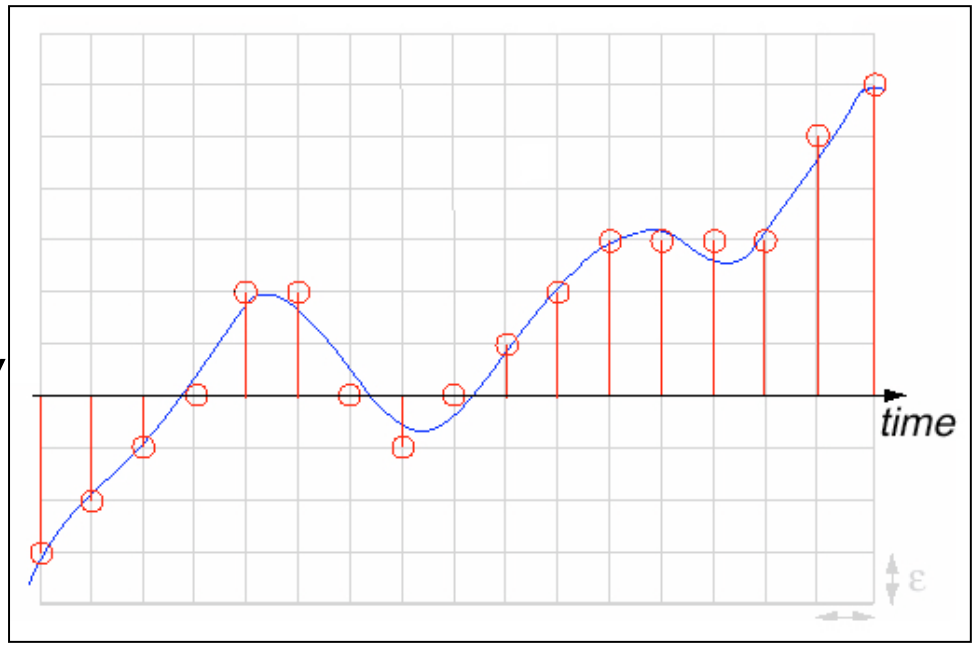
- Most natural sounds are more complex than simple sine waves
  - Can be modeled as sums of more simple waveforms; or, put another way:
  - More simple waveforms mix together to form complex sounds



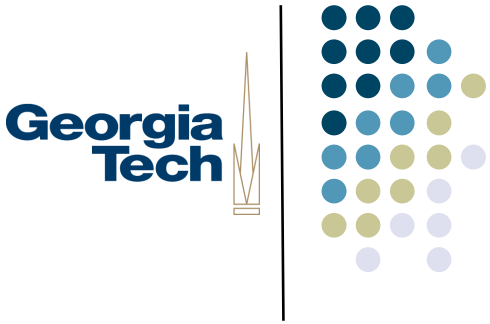


Sampling Audio

- Sampling rate affects accurate representation of sound wave
- Nyquist sampling theorem
- Must sample at 2x the maximum possible frequency to accurately record it
- E.g., 44,100 Hz sampling rate (CD quality) can capture frequencies up to 22,050 Hz



Additional Properties of Audio that can be Exploited to Good Effect



- Sound localization
- Auditory illusions

Sound Localization

- We perceive the location of where a sound originates from by using a number of cues
  - Inter-aural time delay: the difference between when the sound strikes left versus right ears
  - Perhaps most important: *head-related transfer function*: how the sound is modified as it enters our ear canals
- We can take a normal sound and *process it* to recreate these effects
  - Calculate and add precise delay between left and right channels
  - Apply a filter in realtime to simulate HRTF
  - Requires ability to pipe different channels to left and right ears
- Problematic: each person's HRTF is slightly different
  - Because of external ear shape
- Still, can do a reasonably good job
- Generally need head tracking to keep apparent position fixed as head moves

Auditory Illusions

- Example: Shepard Tone
  - Sound that appears to move continuously up or down in pitch, yet which ultimately grows no higher or lower
  - Identified by Roger Shepard at Bell Labs (1960's)
- Useful for feedback where you have no bounded valuator?

Speech versus non-speech audio

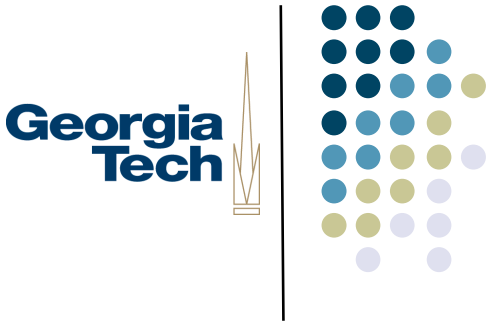
- Speech *is* just audio; why consider them separately?
  - Uses in interfaces are actually vastly different (more on this later)
  - Actually processed by different parts of the brain
- Understanding the physical properties of audio, you can create new interaction techniques
  - Example: "cocktail party effect" -- being able to selectively attend to one speaker in a crowded room
  - Requires good localization in order to work

- In this lecture, we're focusing largely on non-speech audio

Using Audio in Interfaces

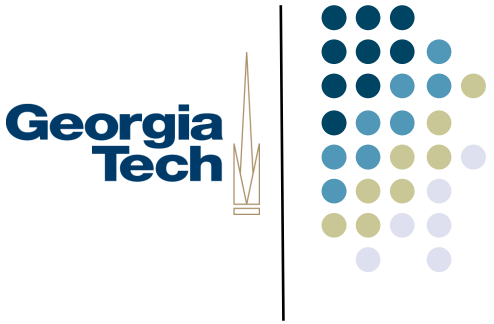
- That's all fine...
- ... but what special opportunities/challenges does audio present in an interface?

Changing the assumptions



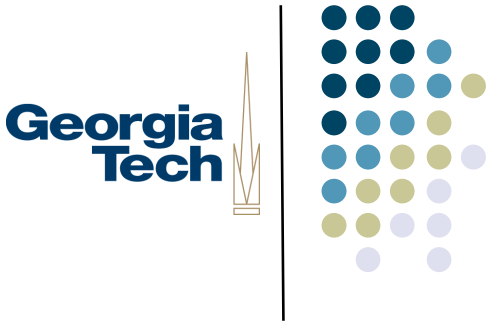
- What happens when we step outside the conventional GUI / desktop / widgets framework?
  - Topic of lots of current research
  - Lots of open issues
- But, a lot of what we have seen is implicitly tied to GUI concepts

Example: "Interactive TV"



- WebTV and friends
- Idea is now mostly dead, but was attempt to add a return channel on cable and allow the user to provide some input
- Basic interaction, though, is similar for Tivo and other "living room interfaces"

- Is this "just another GUI?" Why or why not?



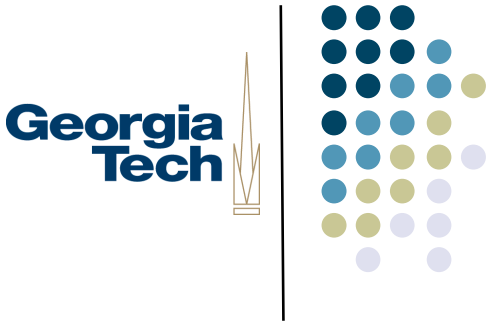
Not just another GUI because...

- Why?

Not just another GUI because...

- Remote control is the input device
  - Not a (decent) pointing device!
  - (Despite having many dimensions of input--potentially one for each button)
- Context (& content) is different
  - "Couch potato" mode
    - only a few alternatives at a time
    - simple actions
    - the "ten foot" interface -- no fine detail (not that you have the resolution anyway)
  - ➡ Convenient to move in big chunks

Preview:
Leads to a navigational approach



Have a current object

Act only at current object

- Typically small number of things that can be done at the object
  - Often just one

Move between current objects

Example: Tivo

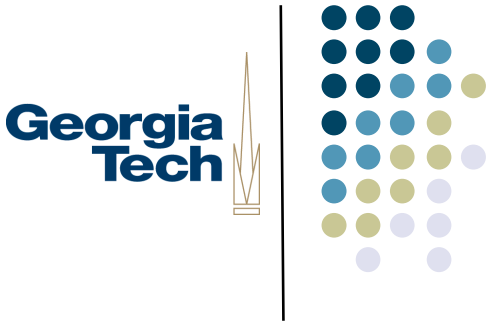
- UP/DOWN
  - Moves between programs
- LEFT/RIGHT
  - Moves to menus/submenus
- At each item, there are a small, fixed set of things you can do:
  - SELECT it
  - DELETE it
  - ... maybe a few others depending on context

Generalizing: Non-pointing input

- In general a lot of techniques from GUIs rely on pointing
  - Example: a lot of input delivery
- What happens when we don't have a pointing device, or we don't have anything to point to?
  - Extreme example: Audio only

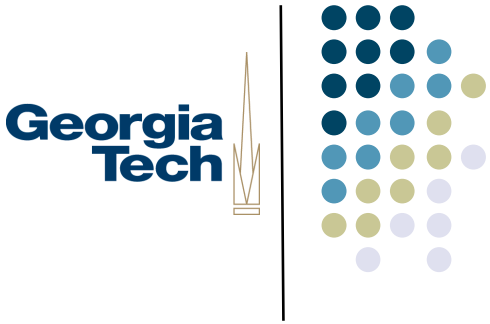
The Mercator System

http://www.acm.org/pubs/citations/proceedings/uist/142621/p61-mynatt/



- Designed to support blind users of GUIs
  - GUIs have been big advance for most
  - Disaster for blind users
- Same techniques useful for e.g., cell phone access to desktop
  - Converting GUI to audio

Challenge: Translate from visual into audio



- Overall a very difficult task
- Need translation on both input and output

Output translation

- Need to portray information in audio instead of graphics (hard)
  - Not a persistent medium
    - Much higher memory load
  - Sequential medium
    - Can't randomly access
  - Not as rich (high bandwidth) as visual
  - Can only portray 2-3 things at once
    - One at a time much better

Mercator solution

- Go to navigational strategy
  - only "at" one place at a time
  - only portray one thing at a time

- But how to portray things?
  - Extract and speak any text
  - Audio icons to represent object types

Audio icons

- Sound that identifies object
  - e.g. buttons have characteristic identifying sound
- Modified to portray additional information
  - “Filtears” manipulate the base sound

Filtear examples

- Animation
  - Accentuate frequency variations
  - Makes sound "livelier"
  - Used for "selected"
- Muffled
  - Low pass filter
  - Produces "duller" sound
  - Used for "disabled"

Filtear examples

- Inflection
  - Raise pitch at end
  - Suggests "more" -- like questions in English
  - Used for "has sub-menus"
- Frequency
  - map relative location (e.g., in menu) to change in pitch (high at top, etc.)

Filtear examples

- Frequency + Reverberation
  - Map size (e.g., of container) to pitch (big = low) and reverb (big = lots)

- These are all applied "over the top of" the base audio icon
- Can't apply many at same time

Mapping visual output to audio

- Audio icon design is not easy
- But once designed, translation from graphical is relatively straight forward
  - e.g. at button:
    play button icon, speak textual label
- Mercator uses rules to control
  - "when you see this, do that"

Also need to translate input

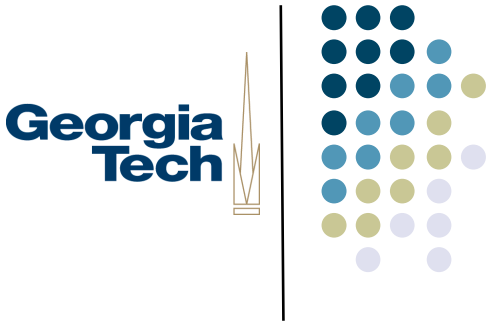
- Not explicit, but input domain also limited
  - Nothing to point at (can't see it)!
  - Pointing device makes no sense
- Again, pushes towards navigation approach
  - limited actions (move, act on current)
  - easily mapped to buttons

Navigation

- What are we navigating?
  - Don't want to navigate the screen
    - very hard (useless?) w/o seeing it
  - Navigate the conceptual structure of the interface
    - How is it structured (at UI level)
    - What it is (at interactor level)

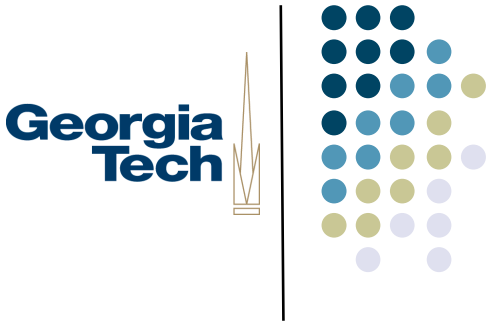
Navigation

- But, don't have a representation of the conceptual structure to navigate
  - Closest thing: interactor tree
  - Needs a little "tweaking"
- ➔ Navigate transformed version of interactor tree



Transformed tree

- Remove purely visual elements
  - separators and "decoration"
- Compress some aggregates into one object
  - e.g. message box with OK button
- Expand some objects into parts
  - e.g. menu into individual items that can be traversed



Traversing transformed tree

- Don't need to actually build transformed tree
  - Keep cursor in real interactor tree
  - Translate items (skip, etc.) on-the-fly during traversal
- Traversal controlled with keys
  - up, first-child, next-sibling, prev-sibling, top

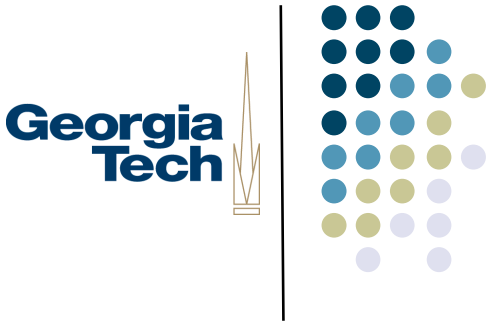
Traversing transformed tree

- Current object tells what output to create & where to send input
  - upon arrival: play audio icon + text
  - can do special purpose rules
- Have key for "do action"
  - action specific to kind of interactor
  - for scrollbar (only) need two keys

Other interface details

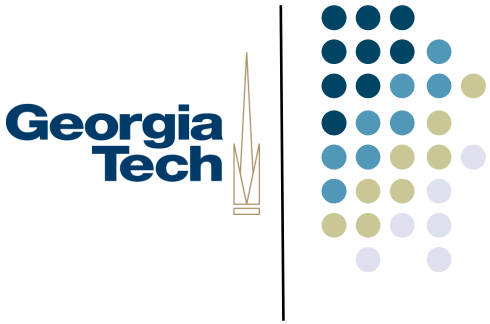
- Also have keys for things like
  - "repeat current"
  - "play the path from the root"
- Special mechanisms for handling dialog box
  - have to go to another point in tree and return
  - provide special feedback

Mercator actually has to work a bit harder than I have described



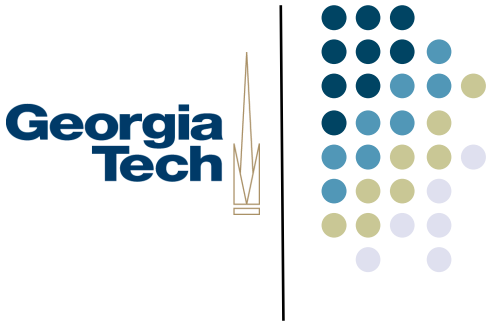
- X-windows toolkits don't give access to the interactor tree!
- Only have a few query functions + listening to the "wire protocol"
  - protocol is low level
    - drawing, events, window actions

Mercator actually has to work a bit harder than I have described



- Interpose between client and server
  - query functions get most of structure of interactor tree
  - reconstruct details from drawing commands
  - catch (& modify) events

Why not just use a toolkit that gives access to the tree?



- To be really useful Mercator needed to work on existing "off the shelf" applications without modification (not even recompile or relink)
  - critical property for blind users

Audio Input

- Most audio input has focused on *speech input*
- However, some work on non-speech input

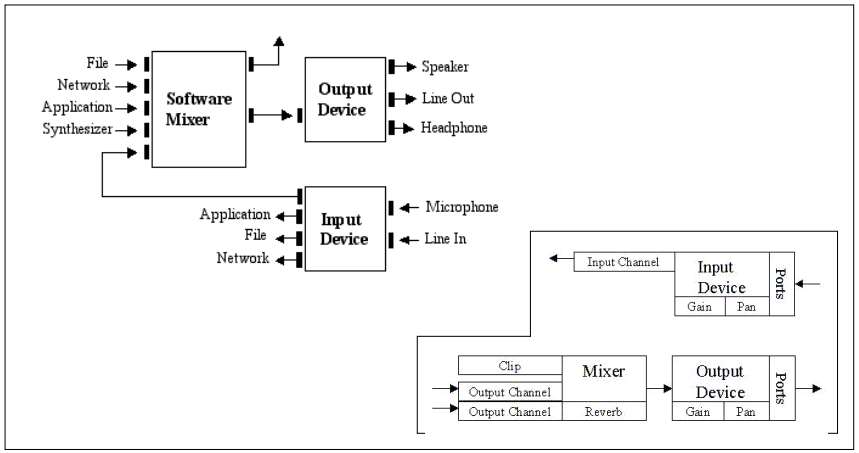
- Example:
  - "Voice as Sound: Using Non-verbal Voice Input for Interactive Control," Igarashi and Hughes, UIST 2001

Question for the class

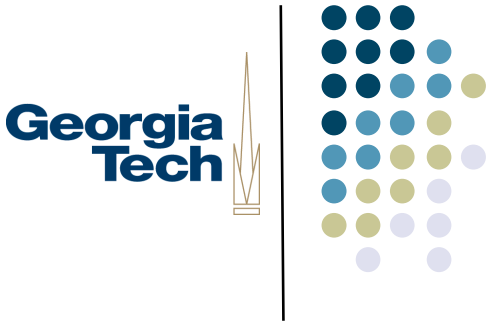
- How would you do drag and drop in audio?

Resources

- JavaSound architecture
  - Insanely good (and under-utilized) architecture for doing powerful audio processing
  - Build on technology licensed from Beatnik, Inc.
  - Company started by Thomas Dolby (the "blinded me with science" guy)



- http://java.sun.com/products/java-media/sound/
- http://www.jsresources.org/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