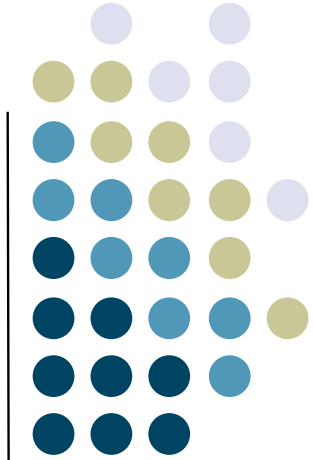
Video in the Interface



Georgia Tech

Video: the BEST* modality

- As passive or active as needed
- Simple directional localization
- Line-of-sight supports see/be seen paradigm (within visible spectrum)

- Rich sensor

* According to a vision person.

Video Details

- Analog vs Digital
  - TV monitors
- Frame rates
  - 10fps for smoothness, 30fps common
- Resolution
  - Broadcast standards (NTSC, PAL, SECAM)
- Interlacing

Video Details (cont'd)

- Color scheme
  - RGB (familiar 3-byte rep)
  - YCC/YUV (Y=luminance, CC=chrominance/hue)

- Formats
  - Analog: composite, S-Video, component

DV standard

- 720 x 480
- 24-bit
- 29.97 fps
- .9 pixel aspect ratio (not square!)
- 44.1kHz stereo audio
- 4:1:1 YCC/YUV

Storing Digital Video

- Single frame of uncompressed video
  - 720 X 486 X 3 = 1049760 bytes ~ 1MB!
  - 1 second = 30MB
  - 1 Minute = 1.5GB
- Must compress
  - Normal Digital Video (DV) is 5:1

Compression

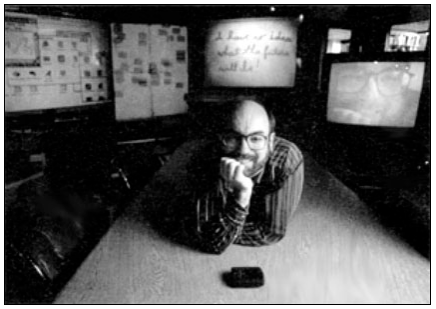
- Reduce resolution
- Reduce frame rate
- Reduce color information
  - Humans more sensitive to luminance than color
- Spatial (intra-frame) vs. Temporal (inter-frame)
- Codec handles compression and decompression of video

Wrapper vs. CODEC

- Wrappers:
  - tif, mov, qt, avi
- CODECS:
  - Sorenson, DV, Cinepak, MPEG II
- CAUTION: Lossy vs. Lossless

Using Video

- Much like other natural data types:
- As data
  - Playback/reminder: useful for humans
- Image understanding
  - Extracting features: interpreted by machines



Motivating Automated Capture

- Weiser's vision: ubiquitous computing

  technology seamlessly integrated in the environment

  provides useful services to humans in their everyday activities

Video (and other natural data types) are a part of the "seamless integration" component of this: make the machine adapt to the person, rather than the other way around

Motivation

- Scenarios in Weiser's *Scientific America* article:

Sal doesn't remember Mary, but she does vaguely remember the meeting. She quickly starts a search for meetings in the past two weeks with more than 6 people not previously in meetings with her, and finds the one.

Sal looks out her windows at her neighborhood. Sunlight and a fence are visible through one, and through others she sees electronic trails that have been kept for her of neighbors coming and going during the early morning.

Defining Capture & Access

- Recording of the many streams of information in a live experience and the development of interfaces to effectively integrate those streams for later review.

- Most often: in video-as-data mode

Capture & Access Applications

- Automated capture of live experiences for future access.

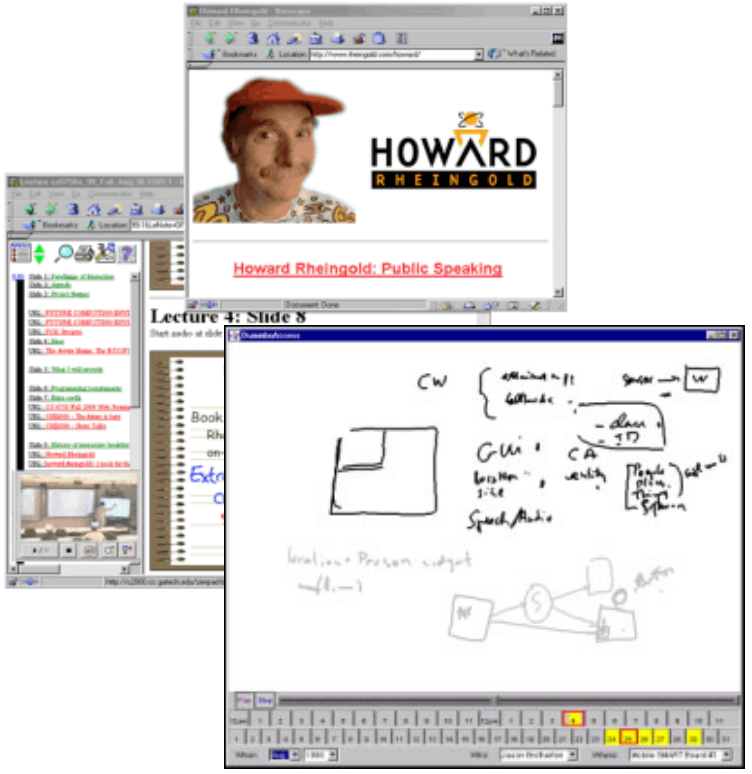
natural input

indexing

ubiquitous access

Capture & Access Applications

- Augmenting devices & environments with a memory



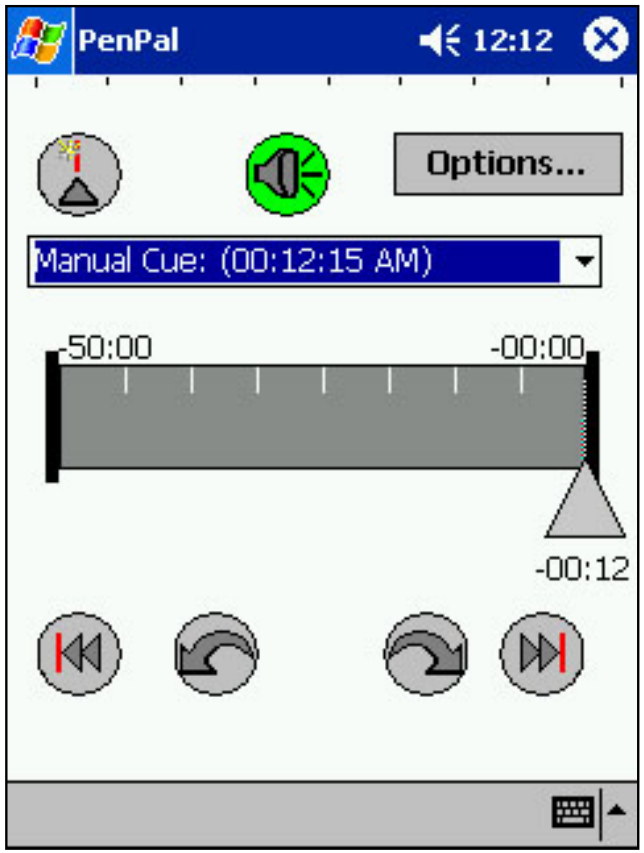
Capture & Access Design Space

- Benefits of automated capture and access have been explored in a number of domains, such as:
  - Classrooms: Lecture Browser, Authoring on the Fly
  - Meetings: Tivoli, Dynomite, NoteLook
  - Generalized experiences: Audio Notebook, Xcapture

- Application design space defined by:
  - Who: Users & roles
  - What: Experience & captured representation
  - When: Time scale
  - Where: Physical environments
  - How: Augmented devices & methods

Non-video example: PAL

- Personal Audio Loop
  - Instant review of buffered audio
  - relative temporal index
  - even/ReplayTV like jumps
  - cue/marker annotations
  - rapid skimming/playback



Example: eClass

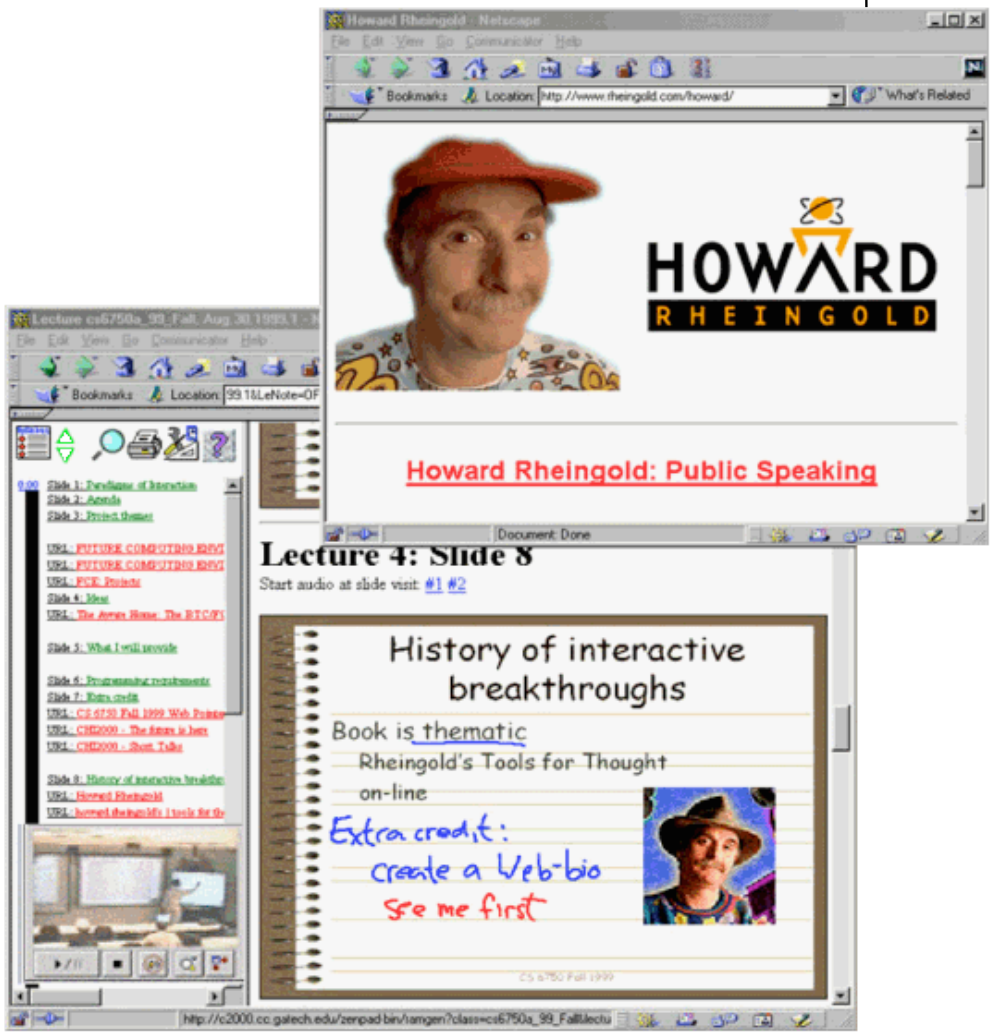
Formerly known as Classroom 2000

electronic whiteboard
microphones

cameras
web surfing machine
extended whiteboard

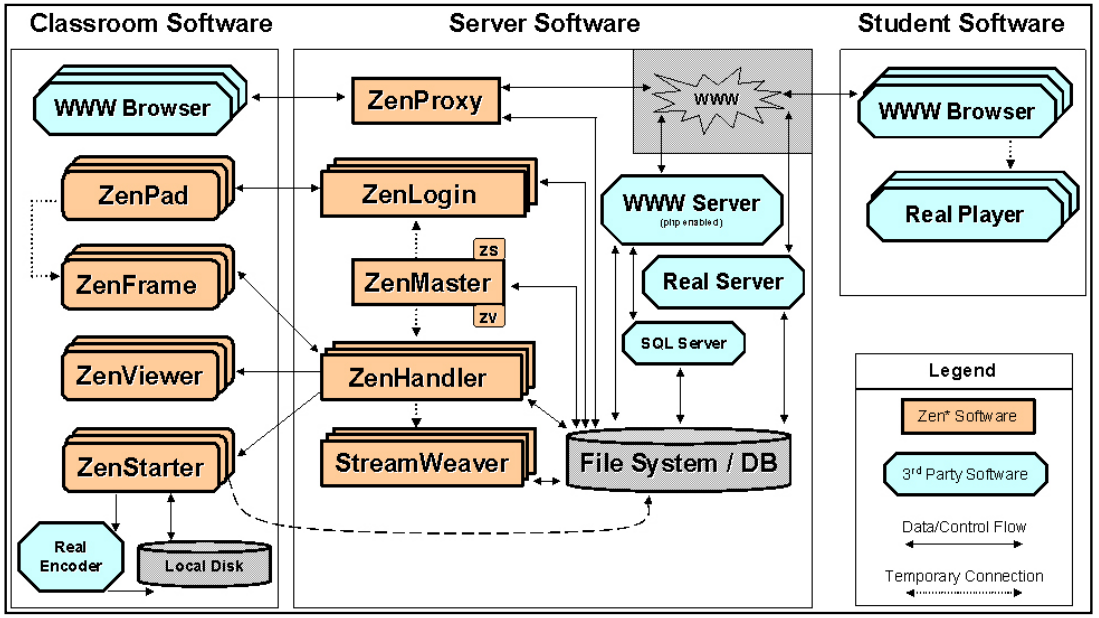
Example: eClass

- synchronize streams
- web access
- Video segmented, indexed based on inputs from other modalities (voice comments, whiteboard marks) without need for video recognition

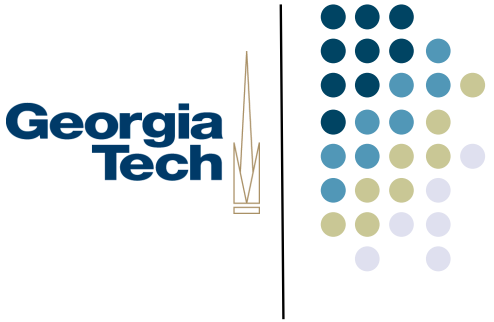


Example: eClass

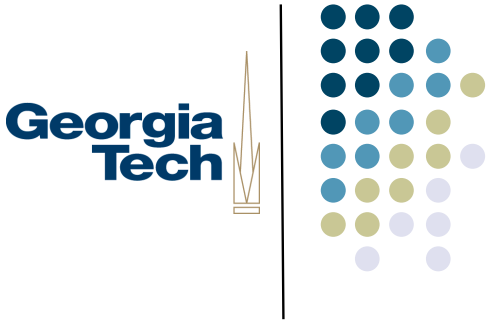
- Segue to ubicomp infrastructures (next lecture)
- Separation of concerns made eClass evolvable for ~6 years
  - pre-production
  - capture
  - post-production
  - access



Building Capture & Access Applications



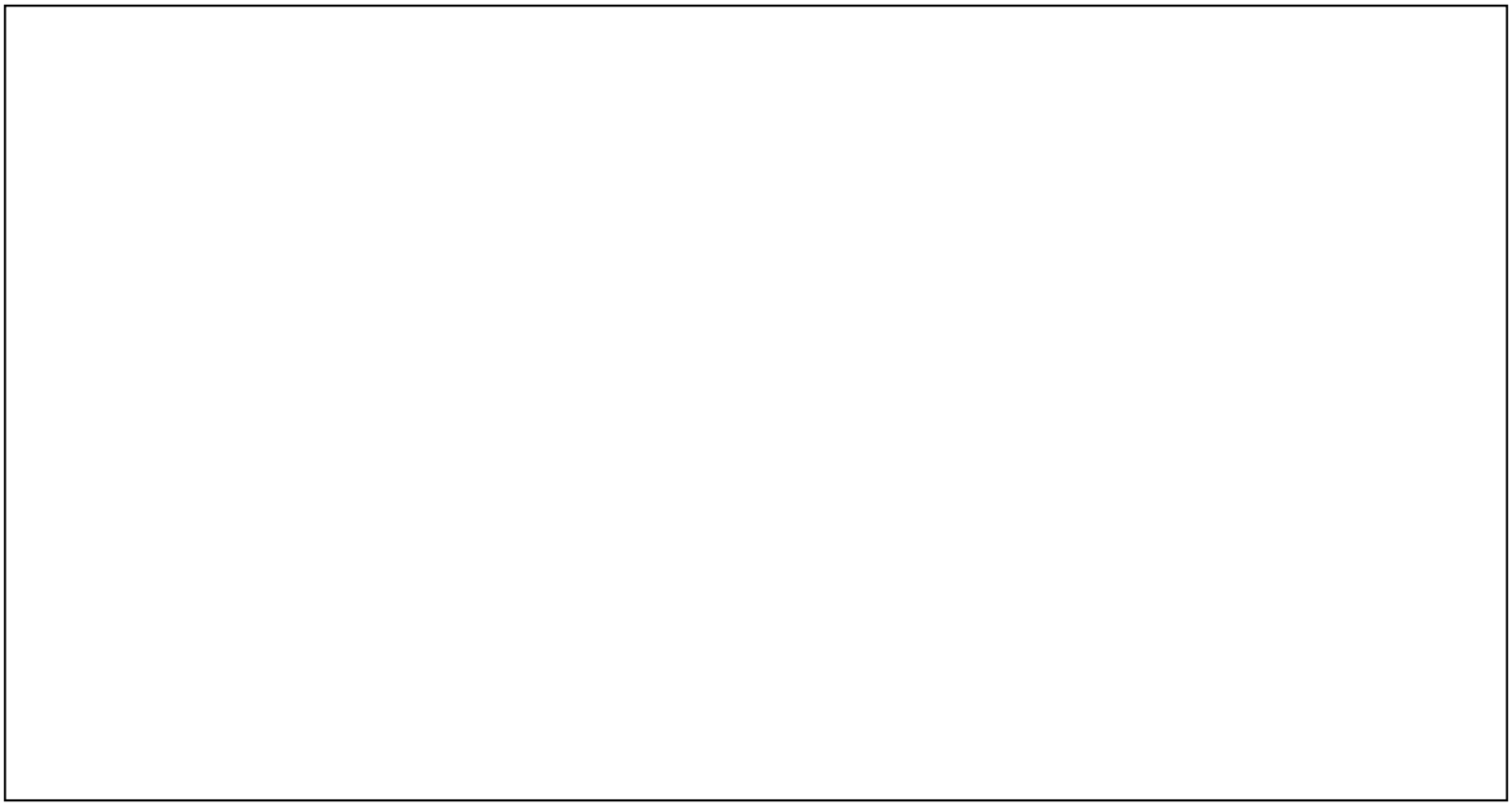
- What are requirements for any infrastructure to facilitate these kinds of applications?



(Infrastructure for Capture & Access)

- Infrastructure aimed to facilitate the development of capture and access applications.

INCA architecture



INCA architecture

Capturer

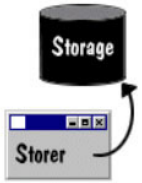
tool for generating artifact (s) documenting history of what happened.

INCA architecture

Accessor

tool for reviewing captured artifact(s)

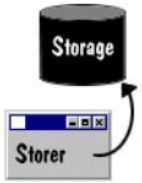
INCA architecture



Storer

tool for storing captured artifact(s)

INCA architecture

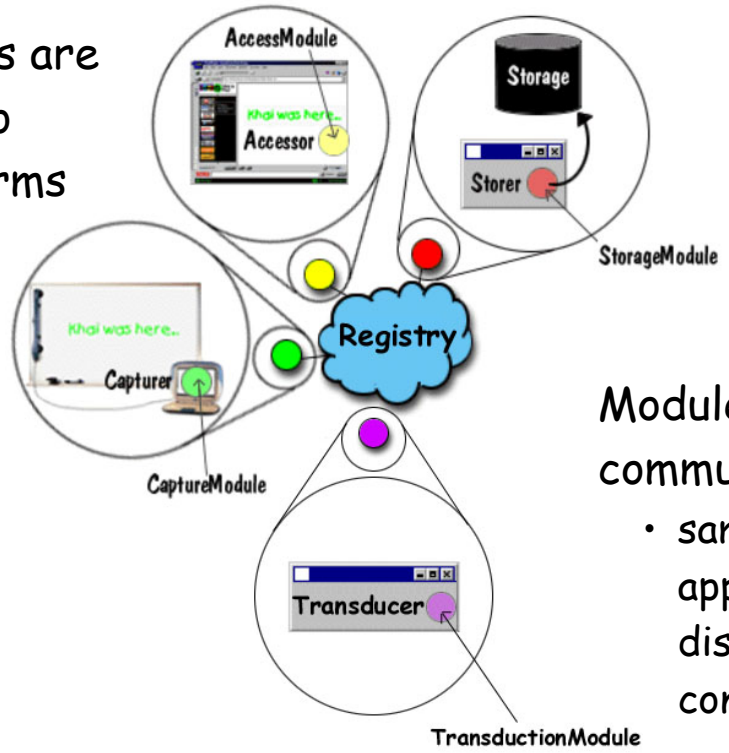


Transducer

tool for transforming captured artifact(s) between formats & types

INCA architecture

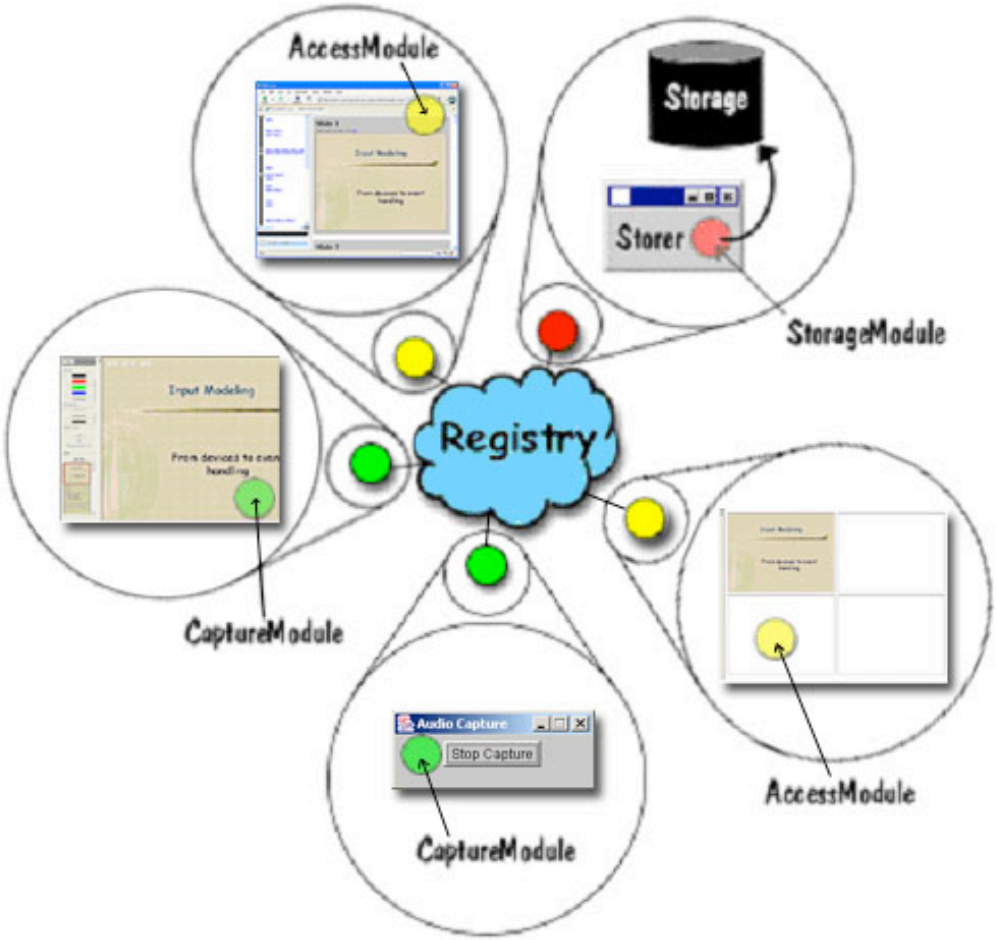
Basic functions are translated into executable forms



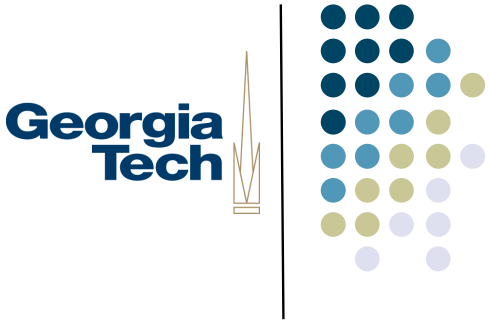
Modules can transparently communicate with each other

- same process for building applications whether it is a distributed system or a self-contained device

eClass in INCA



Information integration & synchronization

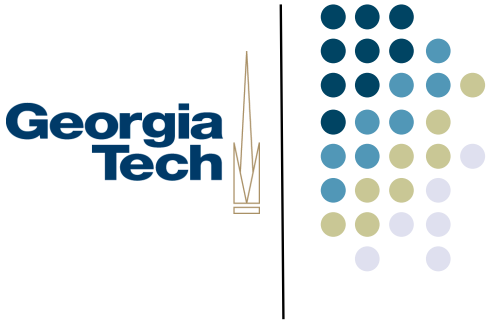


- Support for the integration of information is wrapped into access
- Supports a data-centric model of building capture & access applications:
  - captured data = content + attributes
  - Simple way to specify data being captured
  - Simple way to specify data to access
  - Simple way to associate different pieces of captured data

Additional features

- Additional support is provided to protect privacy concerns
  - Various stakeholders can observe and control the run-time state of an application

Interfaces based on Video Recognition

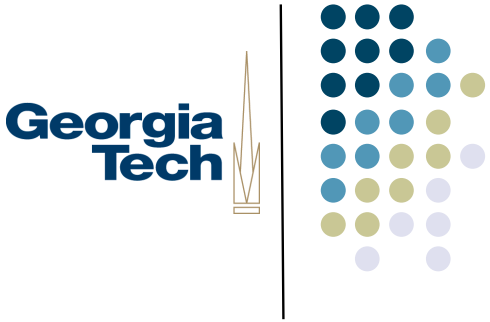


- Generally, has the same problems as using other forms of natural input for recognition
  - Errors, error correction
- Other problems, more-or-less unique to video
  - Unintended input
  - How to give feedback in the same modality?
    - Speech input, speech feedback
    - Video input.... what is equivalent of video feedback?

Image Analysis

- Thresholds
- Statistics
- Pyramids
- Morphology
- Distance transform
- Flood fill
- Feature detection
- Contours retrieving

Recognizing Video Input: AKA computer vision

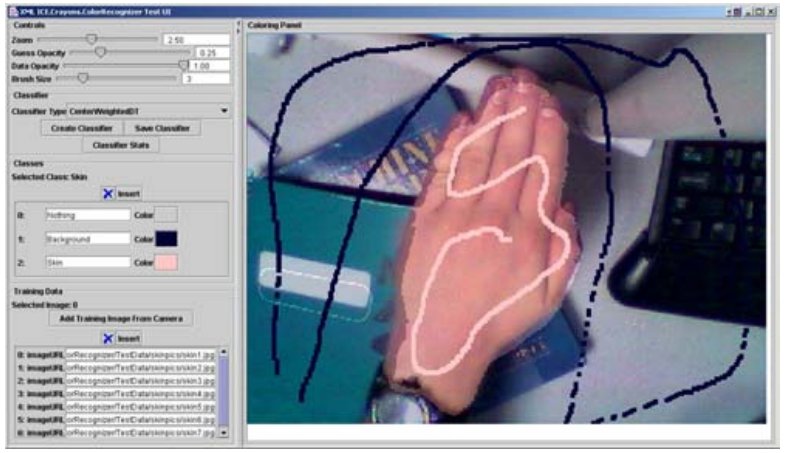


- Often leads to feature-based recognizers
  - Similar to those described for handwriting analysis

- Some work recently on how to make these easier to construct:
  - "Image Processing with Crayons" -- Fails & Olsen. CHI 2003
  - Take sample video images
  - "Color" over them to indicate positive and negative samples
  - System generates classifier based on most salient features
  - Easy to integrate into other applications without ML programming

"Image processing with crayons"

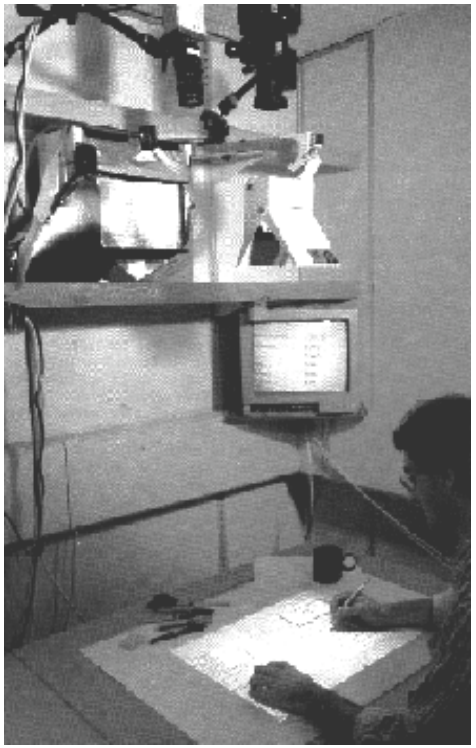
- Addresses problems with how developers create machine learning-centric interfaces without having to know much about machine learning
  - Wide range of sample *features* that are useful for vision built in to the system
  - Features: computed characteristics of input that can be compared to some template using a distance function



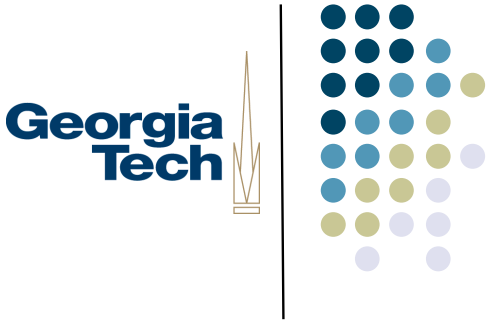
  - Most ML algorithms assume that substantial time will go into feature selection during development/testing
  - Implementing features can be difficult (complex convolution kernels, for example)
- "Coloring" successive samples tells the system how to pick features that provide the highest level of disambiguation
  - Generates classifier automatically based on training data
  - You can run classifier on additional data to see how it performs, mark up areas that it gets right/wrong

Other Recognition-Based Interfaces

- DigitalDesk
  - Recall from movie day
  - Two desks:
    - Paper-pushing
    - Pixel-pushing
  - Applications:
    - Calculator
    - Paper Paint
    - etc.
- Very simple "recognition"
  - Background subtraction from projected image to find occluded areas
  - Assume finger shape, tap sound used to trigger action
  - Other approaches: offset camera, look at when object and shadow collide



Other Recognition-Based Interfaces



- ScanScribe
  - Saund, UIST'03. Interaction with images drawn on a whiteboard through video
  - Available for free download from PARC:
    - http://www.parc.com/research/projects/scanscribe/
  - (Not just useful for video... perceptually-supported image recognition)
- ZombieBoard
  - Saund
  - Combines video image as data with video image as command
  - Whiteboard capture tool

Support for Video in the UI

- Java Media Framework (JMF)
  - Handling raw video
  - http://java.sun.com/products/java-media/jmf/
- Vision
  - VIPER Toolkit (Maryland)
  - http://viper-toolkit.sourceforge.net/
  - Intel's OpenCV
  - http://sourceforge.net/projects/opencvlibrary/