25th February 2020

CSCM39/CSDM001: Human Computer Interaction

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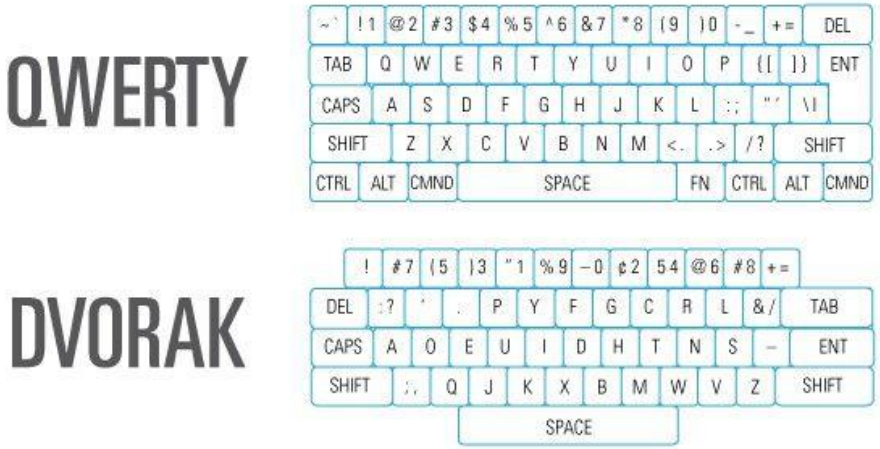
Office Hour: Thursday 2-4pm

Input and Output Mechanisms

Keyboards

- QWERTY layout
  - Minimize pressing of neighboring keys in succession to prevent jams in typewriter
  - Layout carried over for electronic input
  - 60-100 words/minute (wpm)
- DVORAK layout
  - Alternative, less popular layout
  - Reduces awkward strokes
  - Highest frequency keys in middle row
- Ergonomic keyboard
  - Keep standard layouts, but shaped to reduce stress on wrists and fingers



Keypads

- Numeric keypads
  - Phones, ATM's, calculators, cash registers, etc.
  - Different layouts
- Multi-tap text entry
  - Multi tap to select letter
  - 10 wpm
- Predictive text, e.g. T9 (text on 9 keys) system
  - Single taps, with selection for ambiguous cases
  - 20 wpm

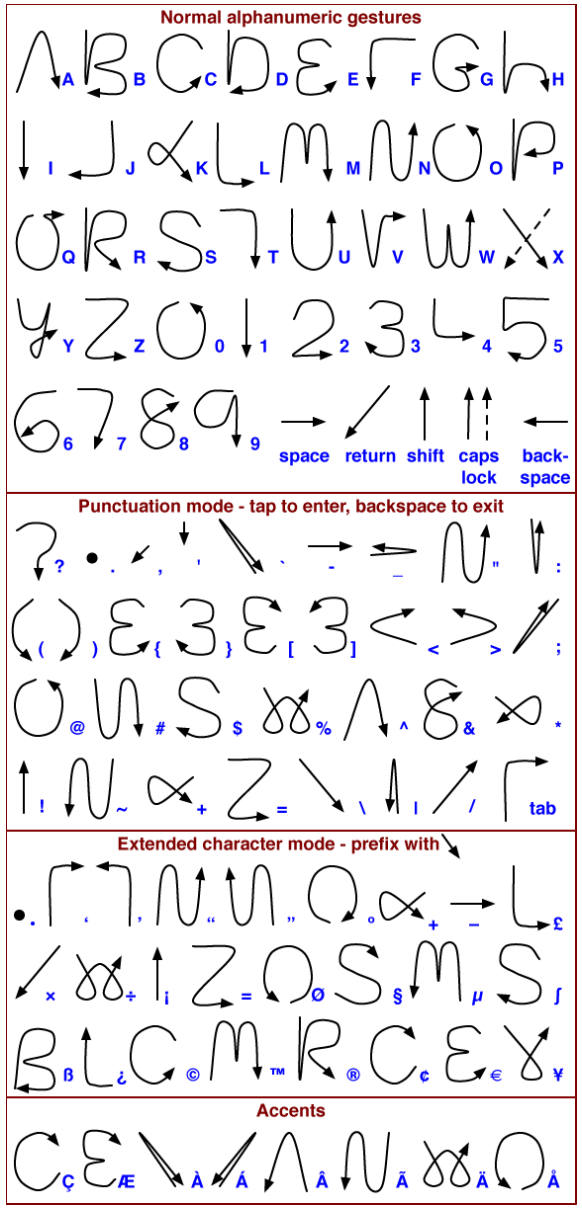
Chording devices

- Chording: pressing multiple keys simultaneously
- Stenotype
  - Very fast typing, e.g. for transcription in law courts
  - Speed record 375 wpm!
- Chorded keysets
  - Used for fast single-handed text entry (50 wpm)
  - Not so popular because of slow learning curve, but used in wearable computing community, e.g., e.g. Twiddler, EkaPad, FrogPad

www.youtube.com/watch?v=6t7-IarTESc,
www.youtube.com/watch?v=I333oAGSOwk
www.youtube.com/watch?v=RNsrfaHl9kI

Handwriting

- Single letter recognition
  - May be available on stylus-based PDAs
  - Useful for very limited space for handwriting
- Cursive handwriting recognition now available on tablet PCs with good accuracy
  - Very useful for “logographic” languages such as Chinese
  - Also for math equations



Speech recognition

- Continuous speech recognition
  - Speaker dependent
    - Trained for specific speaker for accuracy
    - Dragon NaturallySpeaking ~ 98% dictation accuracy under low-noise conditions
  - Speaker independent
    - Multiple speakers without additional training
    - Accuracy still poor, especially when noisy
- Spoken command recognition
  - Recognize command words or command phrases, e.g., phone dialog systems, Siri
  - Usually speaker independent
  - Accuracy high because range of commands very limited, and use of context

Word input speeds

- Words per minute (WPM)
- Standardized word = 5 symbols
- Keyboard speed tests online, e.g. at http://speedtest.aoeu.nl/

Type	Experience User	Professional
Stenotype	180	230
Speech	100-150	250 for auctioneers, but software cannot yet process at this rate
QWERTY keyboard	60	100
Twiddler	50	
Handwriting	30	
T9	20	
Graffiti	15	
Multi-tap keypad	10	

Relative Pointing

- Most map velocity of device to digital velocity on screen
  - Nonlinear: scale factor increases with speed
- Mouse
  - Pointing, clicking, scrolling
- Trackball
  - “Inverted ball mouse”
  - No space issues, used in some laptops
- Touchpad
  - Finger replaces mouse, clicks by taps

Absolute pointing

- Direct pointing to actual position on screen
- Stylus-based displays
  - Great accuracy, but requires stylus
- Aimed pointing
  - Larger displays: interaction at a distance
  - Lower accuracy / less steady
  - Device-based (e.g., Wii pointing)
  - Natural pointing with arm/finger
  - Tiring

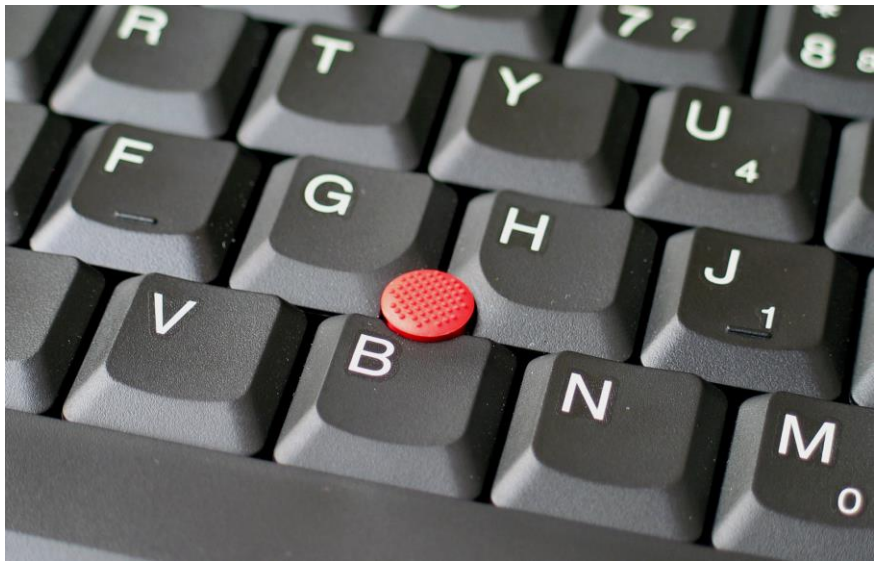
Multi-touch

- Multi-touch devices allow more complex interactions beyond normal pointing or dragging
  - Rotation, scaling
- Smartphones, tablets
- Surface computers
  - Multiple users per display
  - May also interact with tagged physical objects

www.youtube.com/watch?v=1M_oyUEOHK8

Steering

- Map displacement of device to digital velocity
- Pointing stick (IBM TrackPoint)
- Gaming input devices
  - Joysticks
  - Gamepads



Eye-tracking/Eye-gaze

- Cameras or other sensors track position or orientation of eyes or other parts of body
- Transform raw data into detailed descriptions of “paths” of visual focus
- Challenges
  - Interpretation of eye movements
    - Eyes constantly in motion
      - Rapid eye motions – saccades – help us focus
      - Larger motions indicate change of focus
    - “Dwell” - relatively little motion indicating focus on a target
      - Thresholds for identifying a “dwell”
    - Mapping eye-gaze data to screen coordinates
  - Expense of equipment
    - Although commercial products now available for < $200
    - Low-cost alternatives based on USB webcams may be possible

Use for eye-tracking

- Assistive technology
- Pointing and selecting
- Placement of target in list of link
- Length of text summaries for search results
- Eye movement during menu selection
- Fixation vs. movements in specific directions - “sweeps”
- Etc.

A web page annotated with eye-tracking data: lines indicating gaze paths link fixation points annotated with time stamps, providing a trail for a series of interactions.

From Card, S.K., Pirolli, P., Van Der Wege, M.M., Morrison, J.B., Reeder, R.W., Schraedley, P., Boshart, J., 2001. Information scent as a driver of Web behavior graphs: results of a protocol analysis method for Web usability. In: Proceedings of the SIGCHI conference on Human factors in computing systems, Seattle, Washington, United States. ACM. © ACM.

Natural 3D motion

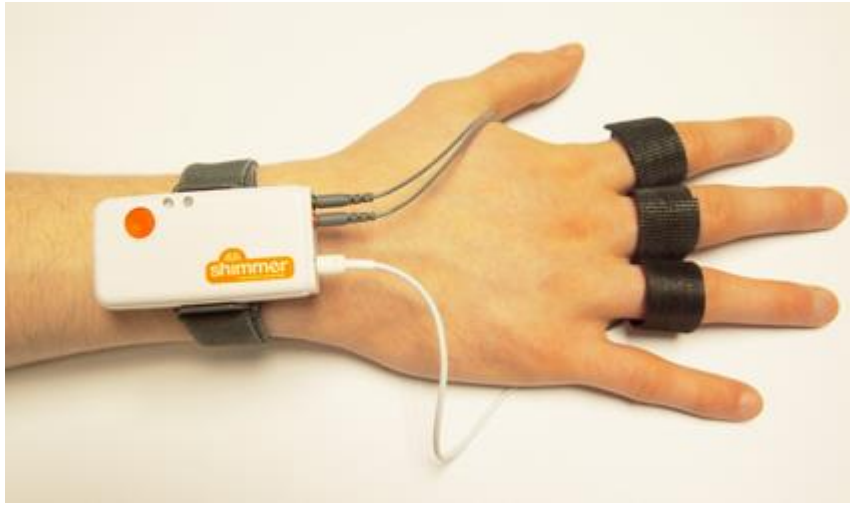
- Device direction sensing
  - Tilt sensors and/or electronic compasses
    - Found in various phones, cameras, etc.
  - Get vertical inclination and/or horizontal bearing, e.g. detect orientation modes, align maps
- Device motion sensing
  - More accelerometers to sense full motion, e.g. Nintendo Wii
  - Partial motion from cameras, e.g., augmented reality phone games
- Body posture and motion sensing
  - Microsoft Kinect
    - Based on structured light 3D sensing
    - Can sense posture of all limbs

Physiological tools

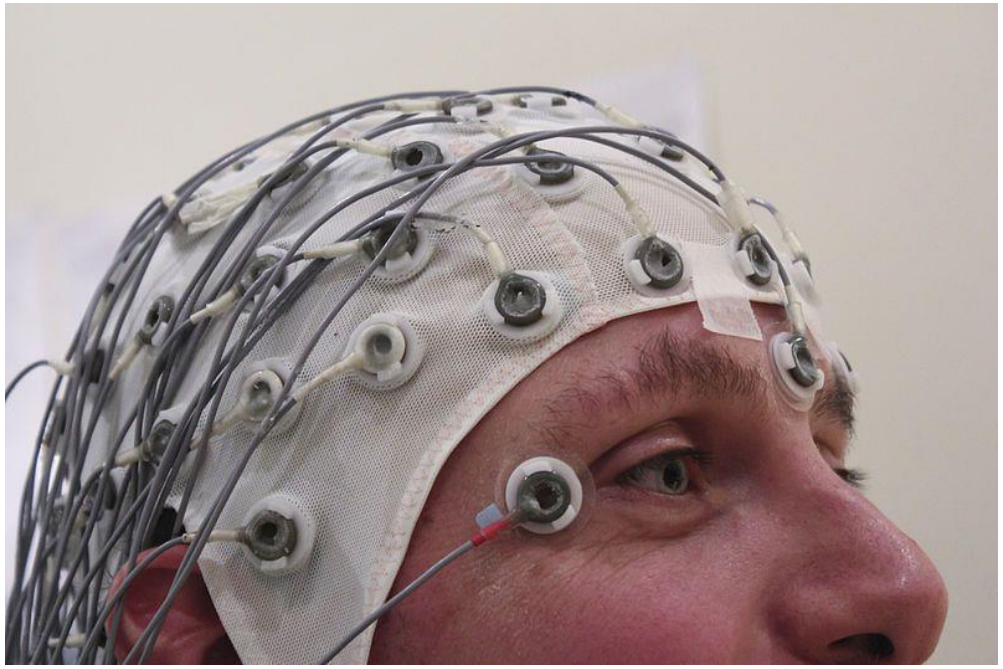
- Bodies change behavior with stimuli
- Measurable differences when we are excited, frustrated, aroused…
- Measurements from bodies can be used to understand these response
- Use physiological signals to measure stress and emotional responses

Types of Physiological data

Data source	Technique	Possible locations	Sensors
Electrodermal activity	Galvanic skin response (GSR)	Fingers, toes	Surface electrodes
Cardiovascular data	Blood-volume pressure Electrocardiography	Finger Chest, abdomen,	Surface electrodes
Respiration	Chest contraction and expansion	Thorax	Stress sensor
Muscular and skeletal positioning	Pressor or position sensing	Varied	Pressure sensor, fiber optics, others
Muscle tension	Electromyography	Jaw, face	Surface electrodes
Brain activity	Electroencephalography Evoked responses	Head	Electrodes in helmet Surface electrodes


shimmer


shimmer

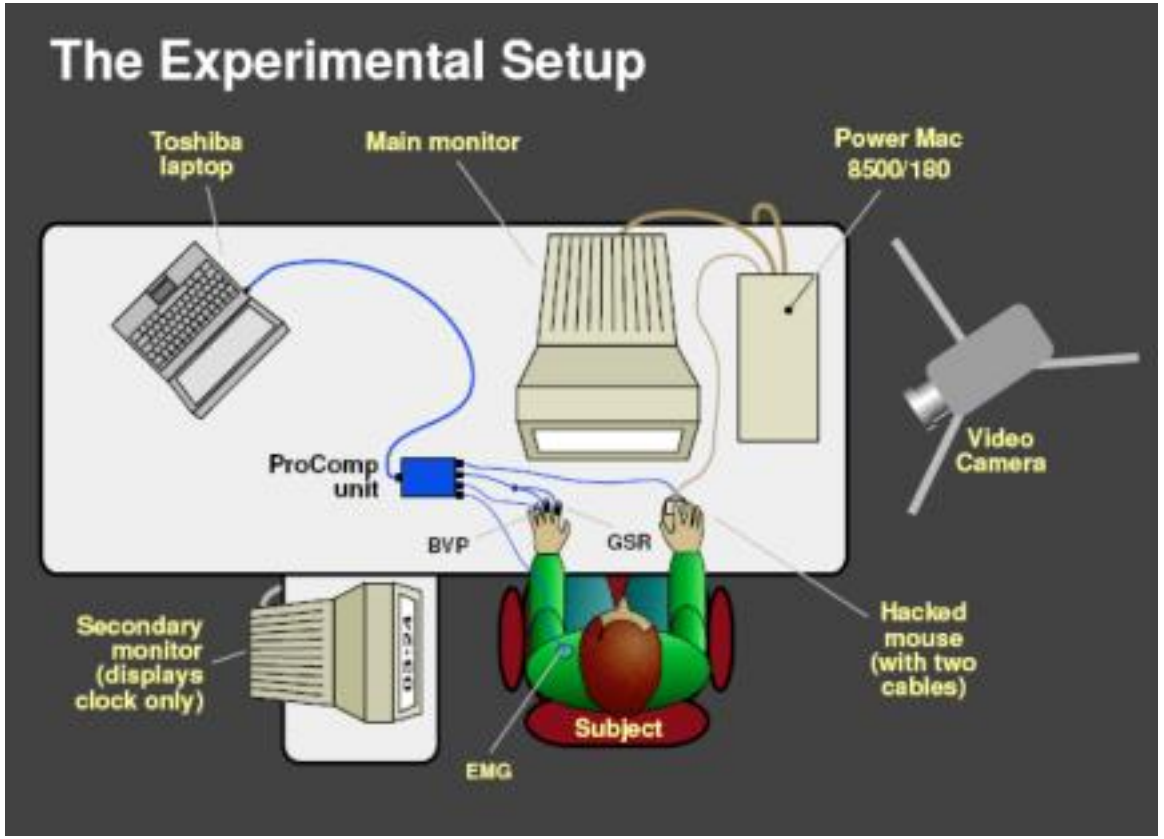


Challenges

- Electrodes and sensors can be difficult to use correctly
  - Get proper training
  - Work with an experienced professional
- Potential discomfort and unease
- Electromyography needles placed in skin
  - Safe, but “Don't try this at home”
  - Use electrodes placed on skin instead

Example

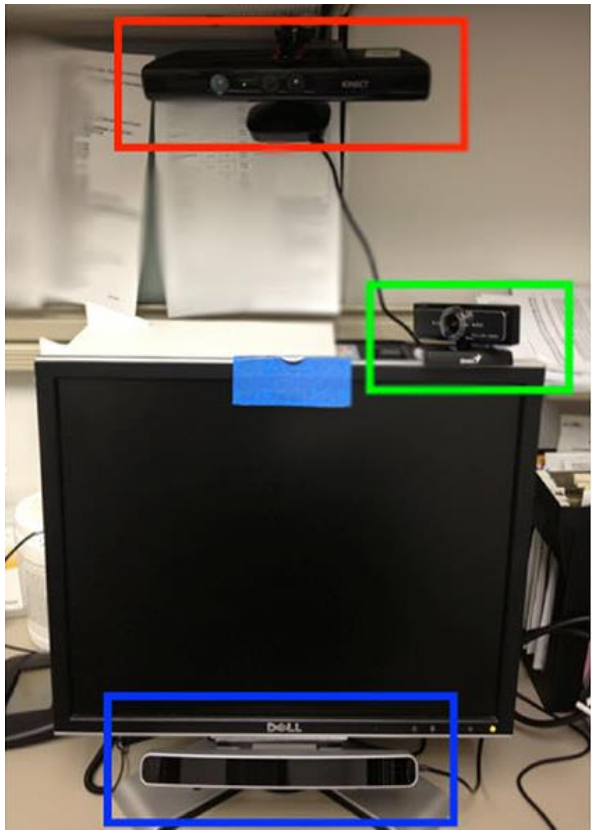
- Two computers
  - Stimulus presentation
  - Recording physiological measurements
- Mouse with two outputs
- Additional display for clock
- Video camera
- Sensors
  - Blood Volume Pressure
  - Galvanic Skin Response sensors



Example: LAB-IN-A-BOX

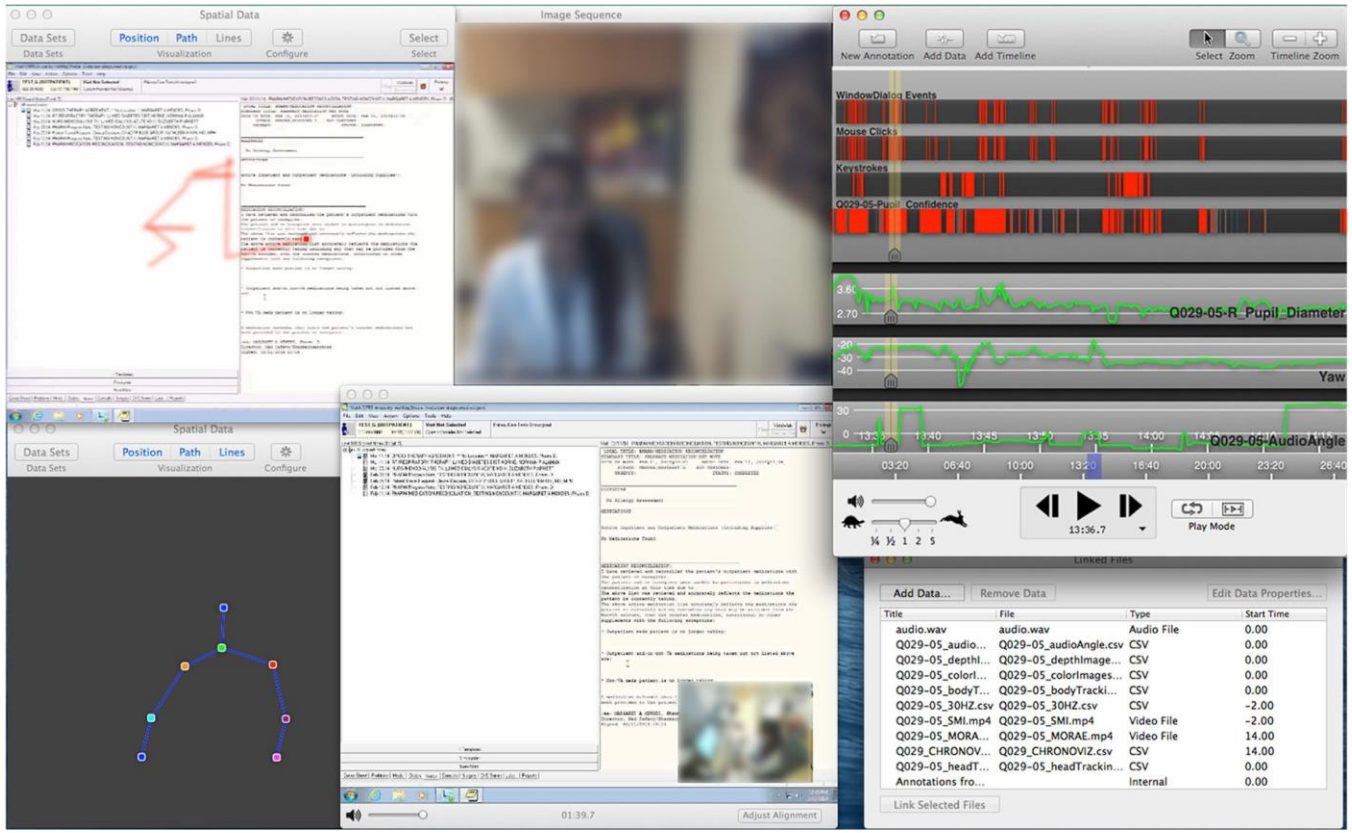
- Electronic medical record (EMR) use during clinic visits
- Understand use of computer and impact on physician-patient interaction
- Audio, video, eye-tracking, keystroke logging, screen-capture, mouse events, Kinect

Example: LAB-IN-A-BOX



LAB-IN-A-BOX components: three sensors are installed around the monitor used by the physician: a Kinect sensor at the top, a digital webcam right above the monitor, and a remote eye tracker below the monitor (Weibel et al., 2014).

From Weibel, N., Rick, S., Emmenegger, C., Ashfaq, S., Calvitti, A., Agha, Z., 2014. LAB-IN-A-BOX: semi-automatic tracking of activity in the medical office. Personal and Ubiquitous Computing 19, 317–334.



LAB-IN-A-BOX data: a series of ChronoViz displays of data captured during a patient visit. Counter-clockwise from upper-left: visualization of the eye-gaze path; body joints from Kinect; Morae video with mouse and room video; synchronization display of the various data sets; a ChronoViz window showing mouse clicks, window events, keystrokes, and pupil data from the eye tracker; and blurred room video (Weibel et al., 2014).

From Weibel, N., Rick, S., Emmenegger, C., Ashfaq, S., Calvitti, A., Agha, Z., 2014. LAB-IN-A-BOX: semi-automatic tracking of activity in the medical office. Personal and Ubiquitous Computing 19, 317–334.

Output mechanisms

- Displays
  - 2D, 3D, multi-view displays
- Audio
  - Earphones / headphones, loudspeakers
  - Text-to-speech
    - Useful when text information needs to be conveyed to a user, who is visually impaired, or whose visual attention is focused else where e.g. road names read out in a GPS navigator
    - Also useful to users with speech disabilities who want to communicate verbally

www.oddcast.com/demos/tts/tts_example.php?clientsw

Output mechanisms

- Haptics
  - Haptics devices provide tactile feedback to users
  - Basic vibration cues
  - Sensation of virtual 3D shapes
- Motion simulators
  - Originally for flight training
  - Now widely used for entertainment
- “4D” experiences
  - 3D visuals
  - Surround sound
  - Tactile input, e.g., wind, water drops
  - Verstibular input – via motion simulation
  - Temperature sensation – cold, heat
  - Olfactory input – via odor release

www.youtube.com/watch?v=iS0EE7DZeO4

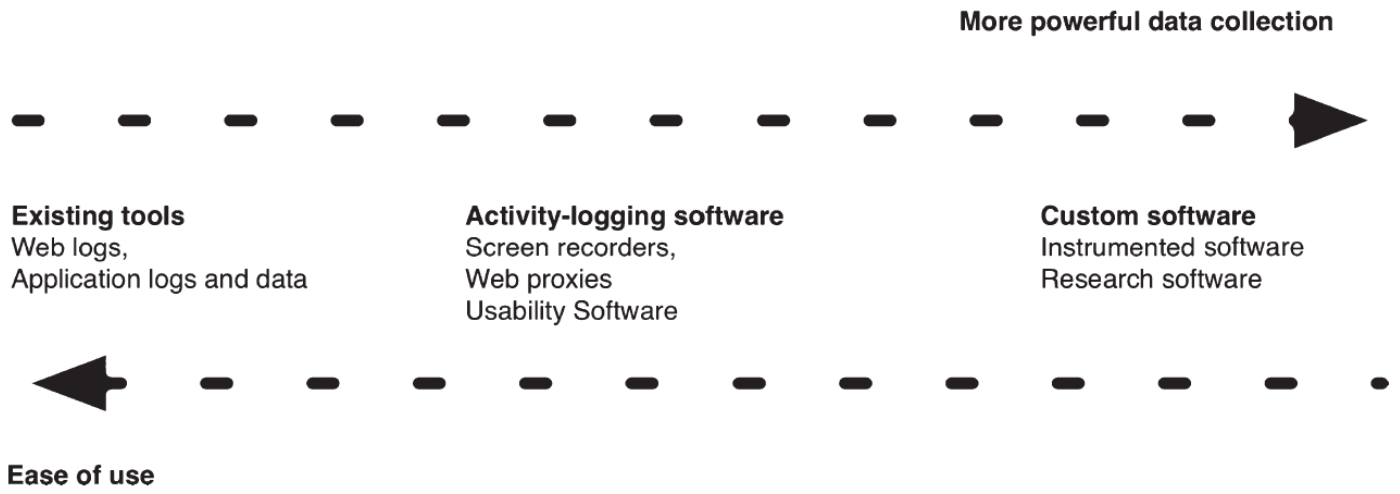
VRLogic CyberGrasp

Sensable Phantom

Automated Data Collection

Automated data collection

- Use the Computer
  - Existing software
  - Activity-logging tools
  - Custom or instrumented tools



Web logs

- Host: the Internet protocol address of the remote computer that made the request
- Timestamp: when the request occurred
- Request: the HTTP request sent by the client to the server
- Status code: a numerical response from the server
- Size (# of bytes): the size of the item returned to the client
- Referrer: the web page that referred the client to the requested resource
- User Agent: the make and model of the web browser that made the request

… and more

Examples

10.55.10.14 - - [13/Jul/2007:13:42:10 -0400] "GET /homepage/classes/spring07/686/index.html HTTP/1.1" 200 8623

10.55.10.14 - - [13/Jul/2007:13:48:32 -0400] "GET /homepage/classes/spring07/686/schedule.html HTTP/1.1" 200 16095

10.55.10.14 - - [13/Jul/2007:13:48:33 -0400] "GET /homepage/classes/spring07/686/readings.html HTTP/1.1" 200 14652

Log file entries, containing host IP address, timestamp, request, status code, and number of bytes.

Web usability & design

- Use Web logs to understand how your site is being used
- Counts of which pages are accessed
- Referrers tell which links (internal or external) are being followed
- Infer paths through the site
- Use insights to drive design

Stored application data

- File systems: The files and folders that we create and use present a model of how we organize information.
- Graphical user interface (GUI) desktops: Some people have dozens of icons on their desktops, while others have only a few. Does this say anything about their organizational preferences?
- Email programs: Many people use an email “inbox” as a todo list, reminding them of tasks that must be completed. Some users make extensive use of filing and filtering capabilities, while others leave all messages in one folder.
- Web bookmarks can also be more or less organized.
- Social networking tools such as Facebook or LinkedIn provide detailed perspectives on how people connect to each other and why.

Activity-logging software

- Software tools specifically used to collect data
- Can be more fine-grained than web logs or stored application data
- Two categories:
  - Proxies: intercept and record user actions before passing them on to end programs.
  - Interaction recording tools: capture screen video and potentially microphone audio, providing a record of what happened and when.

Web proxies

- Widely used for efficiency/security
  - Handle requests from groups of users
- Add additional code for understanding interactions
  - Javascript for mouse movements
- Squid – open source web proxy tool (http://www.squid-cache.org)
  - Need appropriate capacity (bandwidth & servers)

Keystroke and activity loggers

- Local proxies
- Record
  - Mouse movements
  - Keyboard input
  - Window operations
- Very fine-grain
- Sometimes used as “spyware,” to surreptitiously record user interactions in the hopes of stealing passwords, finding evidence of criminal behaviour

Instrumented software

- Modify software to collect data on its own usage
- Log each user action
  - Advantage – can track specific menus, items, etc.
  - Modify existing code
    - Open source
    - Macro and extension facilities

Hybrids

- Multiple forms of automated collection
  - Proxies and instrumented software
- Automated capture + other approaches
  - Observation
  - Qualitative

Online and ubiquitous research

Evolution of HCI research

- Traditionally – desktop computer
- New technologies and uses
  - Mobile/connected devices
    - “Internet of things”
  - Social media
  - Crowdsourcing

Beyond the desktop...

- Online research
  - Using online tools to conduct research
  - Studying online behavior
- Human computation
  - Large numbers of users completing small tasks online
- Sensors and ubiquitous computing
  - ”Internet of things”

Online research

Conducting studies online

- Web conferencing tools
  - Screen capture, audio, webcam, remote/mouse keyboard
- Session recording functionality useful for review
- Installation and configuration can be difficult
  - Test first
- Not limited simply to web-conferencing systems
  - 3D virtual world simulation of a usability lab
  - Webcam-based eye trackers

Online data collection

- Surveys
  - Many free and commercial tools
- Instrumented software, web logs
- Web site design
  - “A/B” testing – different users see different designs
- Consider pairing larger online study with a smaller in-person study

Studying online activity

- Online interactions
  - Communities, social media
- Study how people interact electronically
  - How do ideas develop and spread?
- Although the techniques are very similar to others discussed earlier, the domain is qualitatively different, in that analysis of online activity effectively involves the *emergence of community* and *collective behaviour*

Online communities

- Message boards and other groupings related to some common interest
- Analysis of these communities often combine qualitative and quantitative methods.
- Possibly through downloaded content
- Computerized analysis of text
  - Natural language processing
  - Frequency of use of key words, phrases, etc..

Social media and online interaction data

- Studies of online activity can be classified into three categories
  - Social media studies explore participation in familiar sites such as Facebook, Twitter, etc.
  - Web searches studies examine queries submitted to general Internet search engines
  - Examinations of blogs, wikis, user-generated content explore how users interact in creating and sharing information on the web

Types of social media studies

- Small-scale – small groups or manual analysis of content/comments, etc.
- Larger scale –
  - APIs to capture large datasets
  - Bulk data
    - Easier with public systems like Wikipedia
  - Some analyses might be possible only for employees of larger firms
  - Challenges – data cleansing, indexing, interpretation

Human computation

Human Computation

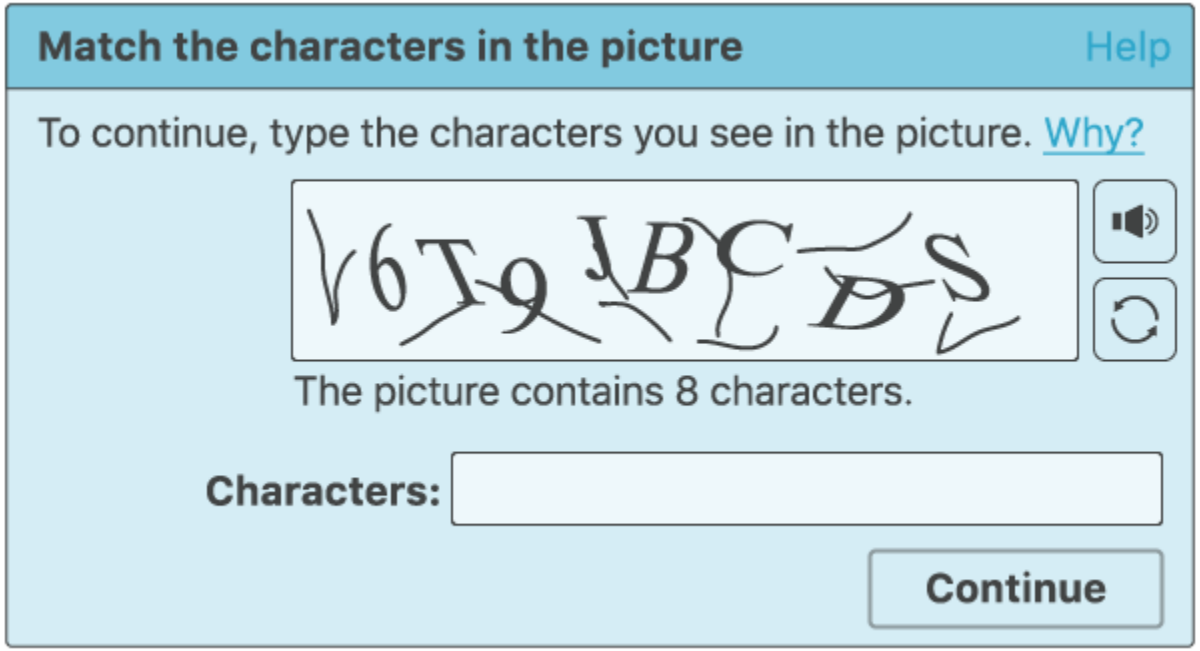
- Computers can do many, but not all, tasks well
  - Software systems evolve to help where humans don't do well.
  - Example – interpreting characters in noisy or detailed pictures
- Tasks that software does not do well?
  - Get humans to help with small piece
  - *Human Intelligence Tasks,* also referred to as *crowdsourcing*
  - When such tasks are explicitly organized with the goal of efficiently finding an accurate solution for a computational problem, the resulting system might be called a *human computation system*

Game with a purpose

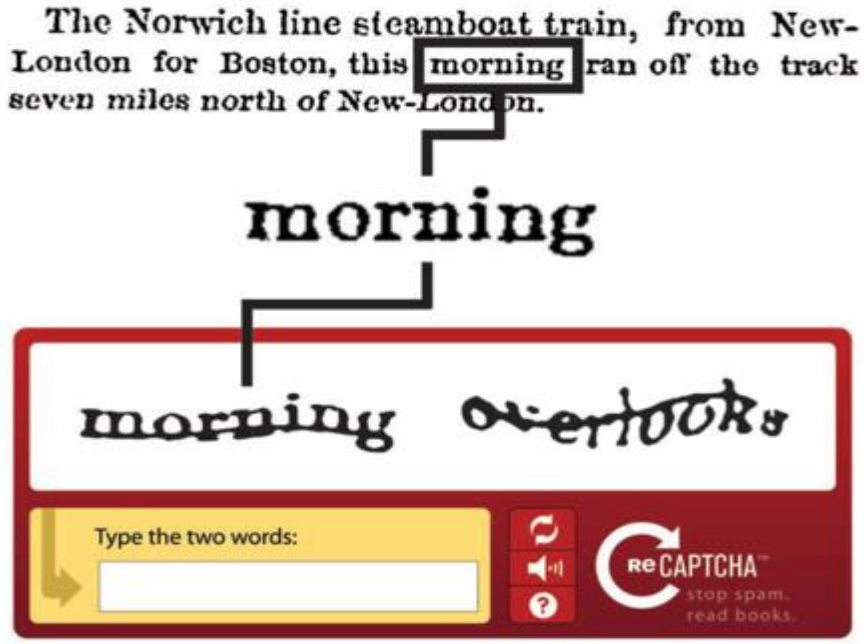
- Problem – get good labels for online pictures
- ESP game
- Ask users to provide labels.
  - When two participants agree on a label, they get points
    - Multiple labelling increases confidence
  - Add additional labels not on the “taboo” list
- Games with a purpose turn image labelling and other tedious tasks into a bit of fun

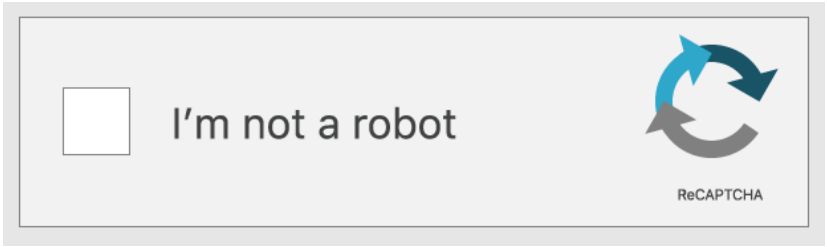
CAPTCHA

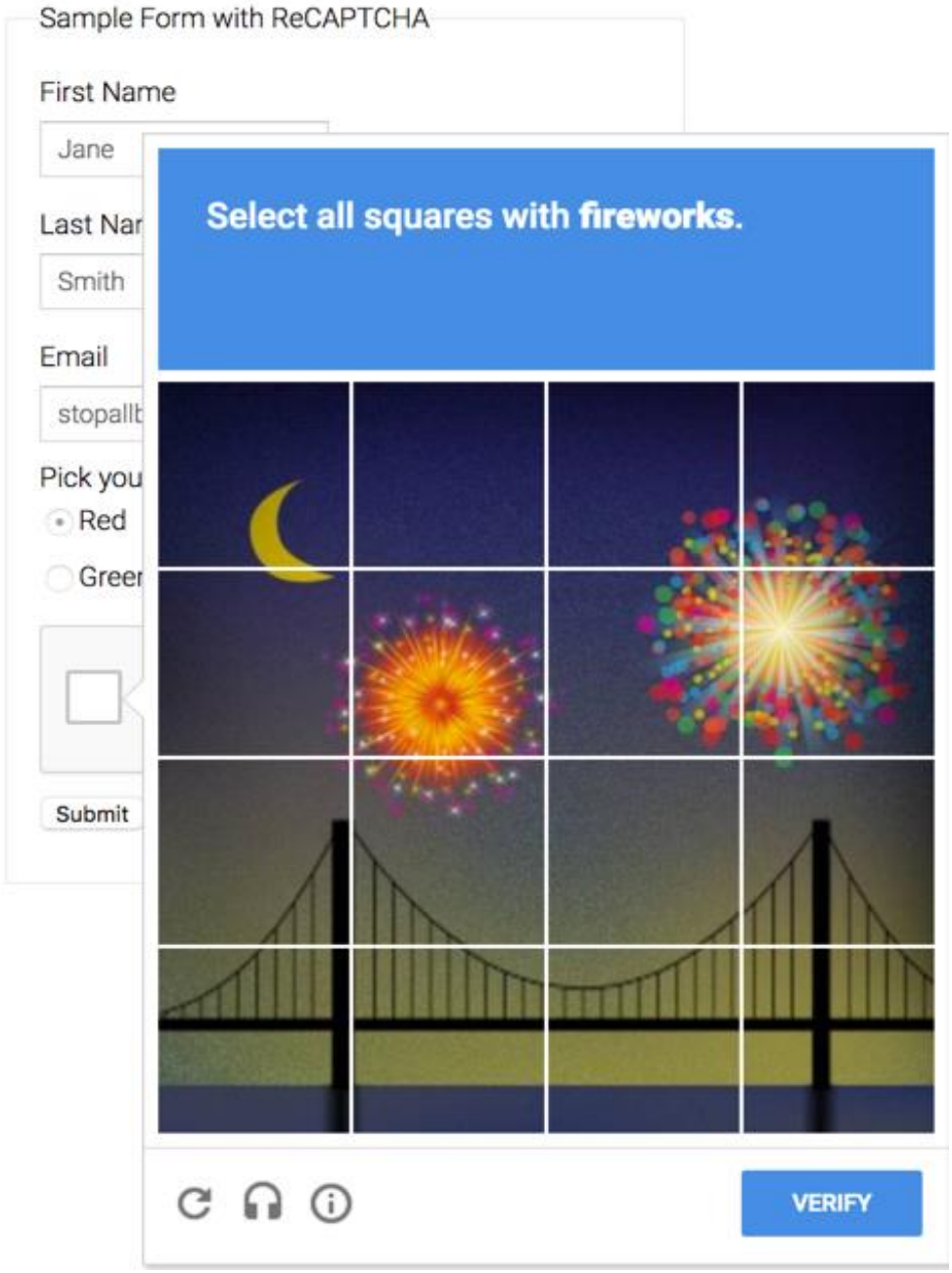
- Completely Automated Public Turing Test to tell Computers and Humans Apart
- Two goals
  - Interpret text that computer vision software can't interpret
  - Make users prove that they are human
    - Prevent bots from registering with online sites



reCAPTCHA


The Norwich line steamboat train, from New-London for Boston, this morning ran off the track seven miles north of New-London.
morning
morning
Type the two words:
reCAPTCHA
stop spam.
read books.


I'm not a robot
ReCAPTCHA


Sample Form with ReCAPTCHA
First Name
Jane
Last Nar
Smith
Email
stopallb
Pick you
Red
Greer
Submit
Select all squares with fireworks.
VERIFY

Crowdsourcing/Human Intelligence studies

- Two types of crowdsourcing studies
  - Systems based on crowdsouced data
    - Annotating research reports to identify discussions of potentially harmful drug-drug interactions
    - extracting relationships between texts and tables in written reports
    - using real-time crowd interpretation of cell phone images to help blind people identify nearby objects
  - Crowdsourced HCI experiments
    - Web-based studies involving large numbers of participants in more or less traditional empirical evaluations of interfaces or visualizations

Concerns: Software infrastructure

- Human computation studies need not have extensive or complex software infrastructure.
- Build a database driven web application
- Commercial crowdsourcing services
  - Mechanical Turk, CrowdFlower, etc.
  - Manage recruitment, task presentation, etc.
  - Tasks and instructions can be created via tools provided by the sites
  - Some add-on toolkits available

Concerns: Tasks & study design

- Tasks must have introductory description, clear definition of success, and incentives
  - Open-ended tasks not applicable
- Concern – users being paid might not take tasks seriously
  - Screening tasks can reject low quality participants or responses
  - Tasks completed too quickly may be low quality
  - Predictive models of # of tasks needed to get good examples

Ongoing work on human computation

- New approaches to explore impact of task order and improve response quality
- Pay workers to be available quickly – real-time crowdsourcing
- Model errors
- Use crowdsourcing to support higher-level tasks such as writing

Sensors and ubiquitous computing

Sensors and ubiquitous computing

- Advances in miniaturization, sensors, and networking
- Large numbers of small devices collecting data
- Now - “Internet of Things”
  - Clothes, glasses
  - Thermostats
  - Security alarms/cameras..
- Low-cost platforms – Arduino & Raspberry Pi

Two types of sensor/ubiquitous research

- Needs assessment/qualitative research
  - What should it do and how should it work
- Assess how tools work in practice
  - Interaction data
  - Observations
  - Case studies
  - Other qualitative analysis

Examples: Sensors and monitoring tools

- Home-based sensors of activity
  - Measure older family members as they go through daily activities
- Use motion sensing (Microsoft Kinect) and smartphone data
- Environmental monitoring
- Microphones on pipes in basement to measure bathroom use
- Activity sensors – active watches, FitBits, etc.

Ubiquitous computing research methods

- Qualitative case studies
- Examinations of the uses of tools in the context
- Methods chosen will also vary with the project

Challenges of sensor data

- Building sensors
  - Use commercial products or components (Arduino or Raspberry PI)
- Data transfer – large data through wireless or USB
- Storing large sensor data
- Analysis - preprocessing, filtering, signal processing, classification
  - Many strategies and toolkits