Context-Aware Systems and UI Design*

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*slides based on Dawei Liu's

Content

- Mobile human computer interaction (HCI)
- Context-Aware Systems

Mobile HCI

Mobile HCI

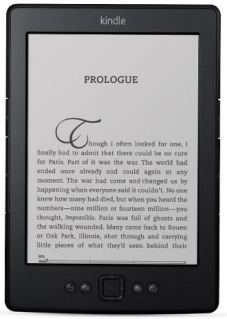
- What is HCI
  - It involves the study, planning, and design of the interaction between people (users) and computers
- From PC to mobile
  - **PC**: static location, fixed wire, powerful display, constant user attention and focus, desk-based input devices, dedicated peripheral support …
  - **Mobile computing devices**: dynamic location, (almost) always available wireless connectivity, intermittent user attention, limited real-estate to support input devices, handheld and movable, constrained display service …

Diversity of Device Interaction

- Devices can be characterised in terms of:
  - **Size**: hand-sized, decimetre-sized, vs body-sized, etc.
  - **Haptic input**: two-handed vs one-handed vs hands free
  - **Single user vs shared interaction**: personal space vs public space
  - **Posture** for user: lying, sitting, standing, walking, etc.
  - **Distance of output display** to input control: centimetre to metre.
  - **Position** during operation: fixed vs mobile

Diversity of Device Interaction

- Devices can be characterised in terms of:
  - **Connectivity**: stand-alone vs networked, wired vs wireless
  - **Tasking**: single task vs multi-task devices
  - **Multimedia content access**: voice and text communications, oriented alpha-numeric data or text-oriented, audiovisual-content access
  - **Integrated**: embedded integrated devices vs dynamically interoperable devices

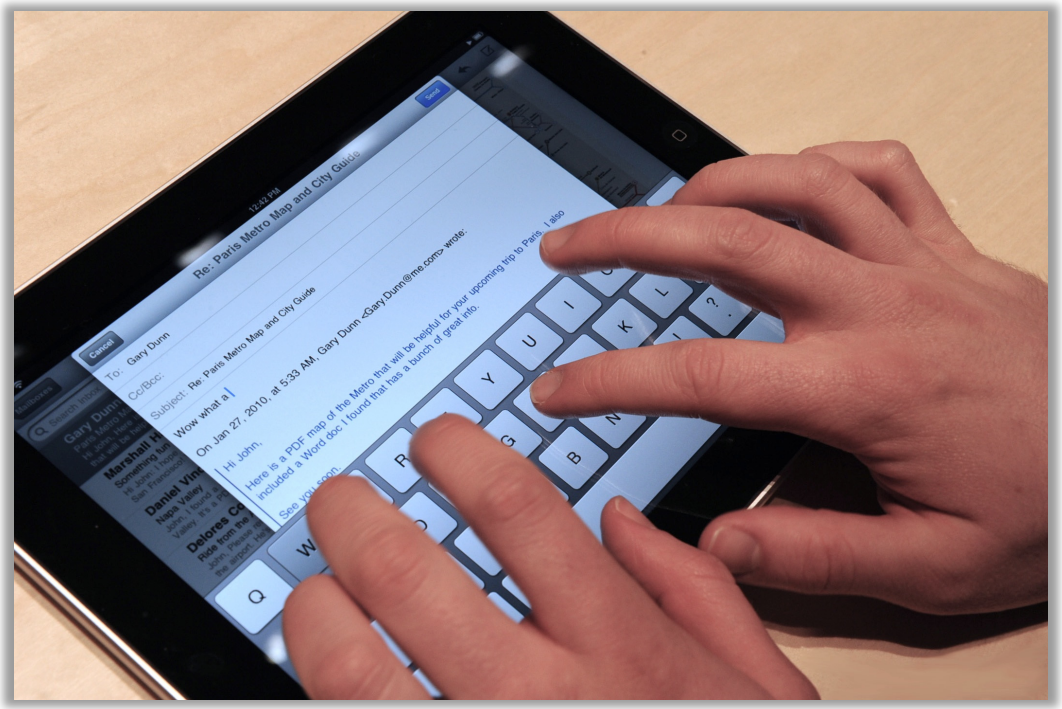


User Input on Mobile Devices

- Commonly used input techniques
  - Keyboards
    - Telephone keyboards
    - Mobile Mini keyboards
    - Touch Screens
  - Voice
  - Novel solutions

Virtual Keyboards (on Screen)

- What are the advantages and disadvantages of virtual keyboards?

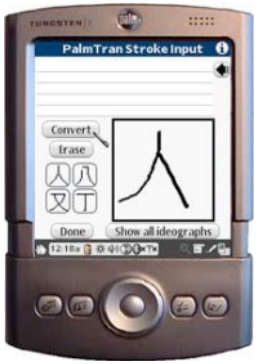


Virtual Keyboards (on Screen)

- Graphical Approach: a keyboard is displayed on the screen
- Pros
  - Simple to use, good for multi-lingual alphabets
  - Save physical space
- Cons
  - Requires accurate input
  - Lack of physical feedback
  - Requires screen real-estate to display keyboard
- Improvement schemes
  - Predictive typing/correction
  - Magnifier cursor

Character Recognition

- Recognizing handwriting based on pen-tip movements and pen-up / pen-down signaling
  - Require high processing power
  - Require training samples of the user's handwriting
  - Error rate is often high



Voice Input

- Speech Recognition
  - Converts spoken words into text or commands
  - Since 20 years ago
    - trained to an individual voice
    - limited to a fixed vocabulary commands at the very beginning
  - Now commonly used in search engine, Call Centers, etc, -typically voice independent

- E.g. Google Voice in Android
- Pros? Cons?

Voice Input

- Advantages
  - Hands free access and control
  - Screen space saved
  - Does not interrupt current interaction activities, such as driving.
- Disadvantages
  - Often processor heavy
  - Susceptible to degradation in noisy environments
  - Difficulty in accent recognition

New Input Solutions

- Virtual keyboard without screen

- Other ideas?

New Input Solutions

- Any other idea?
  - Stephen Hawking's Wheelchair
  - Brain Computer Interface

Securities in Mobility

- Private & sensitive information in mobility
  - Personal information
  - Social networking
  - E-Campus/E-Government
  - E-Banking/E-Purse
  - E-Commerce (e.g. Taobao, eBay, Amazon)
- Security threats
  - Virus
  - Hackers
  - Unauthorized access

Secure Solutions

- Securities in two aspects
  - Device
  - Networking
- Traditional desktop based security
- Security for mobile devices
  - Authentication –security for devices
  - Encryption –security for wireless networking

Authentication

- User authentication (identity verification)
  - Convince system of your identity before it can act on your behalf
- What to verify
  - What you know -password
  - What you have –IC card
- Problems?
  - Password –strength (brutal force), memory (easy forget), input (input in front of others)
  - IC card –portability (hardware incompressible), lack of self-protection

Biometric Authentication

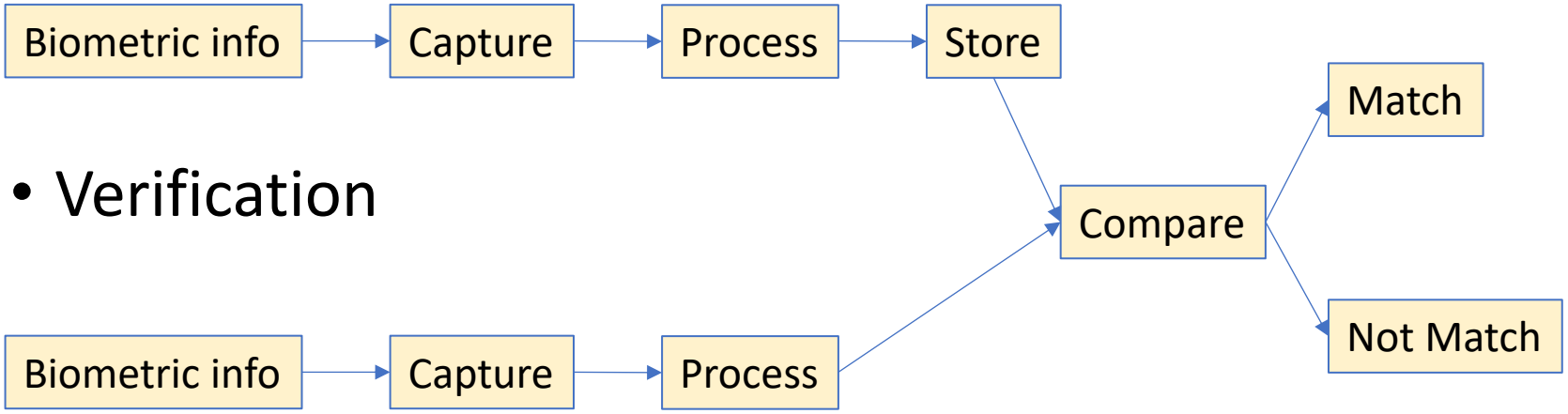
- What to verify
  - What you know - password
  - What you have - IC card
  - Who are you - identity your physical characteristics or behavioral patterns, known as biometrics
- Characteristics used include:
  - fingerprint
  - speech
  - face or body profile
  - signature (usually dynamic)
  - retina pattern

Biometric Information

- What types of biometric information can we use for authentication
  - Universality (Every person should possess this characteristic)
  - Uniqueness (No two persons possess the same characteristic)
  - Permanence (Does not change in time, i.e., it is time invariant)
  - Collectability (Can be quantitatively measured)
- Then it can potentially serve as a biometric for a given application.

Authentication Framework

- User's biometric data must be acquired, assessed, processed and stored in mobile devices in advance.
- Enrollment



- Verification

Biometrics Authentication

- Potential threats?

Context-Aware Systems

Context-Aware Systems

- What is context-aware?
  - Systems that are aware of their own situation in the physical, virtual, and user environment.
    - Weather app shows local weather
    - Music player auto stop when calling
    - Phone locking the screen when it gets close to the face.
- Why context-aware?
  - Apps can be more intelligent and less attention hungry (more comfortable to use, more efficient…).

Context-Aware Systems

- How to be context-aware
  - Adapt users' operation or goal based on contextual cues from the environment or the user's actions
  - Specifically, sense environment and determine what is relevant to the system's task(s)
    - convert raw sensor data into relevant information
    - relevant knowledge model used to comprehend contextual cues and direct behavior

Classifying CA systems

- Passive context-aware systems - new context is presented to the user, to inform them of change.
  - User can then explicitly determine if the use of an application should change
  - E.g Battery running out (trigger an alarm and ask if the users want to take some actions)
- Active context-aware system -behavior of the applications change automatically
  - Task filtering - information filtering, based on current wireless network speed
  - Context-base task activation (changing time zone while travelling)

Classifying CA systems

- Various ways of classifying CA software:
  - Proactive Triggering:
    - performing some interaction based on environmental perceptions
  - Streamlining Interaction:
    - travel guide for current location (reducing irrelevant information)
  - Memories for past events:
    - based on spatial or feature-based cues (contextual retrieval)
  - Reminders for future contexts:
    - tagging details regarding current context for future access
  - Optimizing patterns of behaviours:
    - changing interface based on situation
  - Sharing Experiences:
    - Social networking based on shared contexts

Context Creation

- New contexts can be created based on sensor data (captured by the device or nearby sensors)
  - Lower-level raw contexts -> higher level contexts, raw data may need to be scaled or transformed
    - E.g. electrical signal on a temperature gauge should be converted into a Celsius value...
    - E.g. absolute geo-location position should be converted into an address or identification of a building
  - Abstraction is often more useful
    - e.g. “this photo was taken at my parents home last Christmas”

Examples

- Google Street View Navigation
  - User captures an image of the street view and upload it to the server
  - Google locates the user based on the image
  - Search for relevant geographic information based on the location
  - Display navigation information on the user's image

Challenges in Context Awareness

- Environmental cues may be inaccurate or erroneous
- The user contexts may be incorrectly determined or predicted, or just ambiguous
- Lack of alignment with cues and the internal representation of contexts
- The use of contexts may reduce user privacy
- Awareness of context shifts or changes in application may overload or distract the user

Spatial Awareness

- What is spatial awareness
  - It connects contextual information such as an individual's or sensor's location, activity, the time of day, and proximity to other people or objects
  - It is the key element of Location-based service (LBS)
  - It is often considered one of the main drivers for mobile services
    - Google Map, Yahoo Map, Apple Map, Baidu Map, TigerMap
    - Didi/Uber Foursquare, Yelp, Facebook Places.
    - PokemonGo

Spatially Aware: Examples

- Personal applications
  - Navigation - Give me the direction to the nearest coffee shop
  - Context Change - My route is congested, is there a better route?
  - Tourism - Tell me about the building in front of me
  - Emergency - I’m having a heart attack!
  - Social networking - Any friends nearby?
  - Tagging - Where were those photos taken?
  - Tracking - My phone has been stolen - can it be tracked?

Spatially Aware: Examples

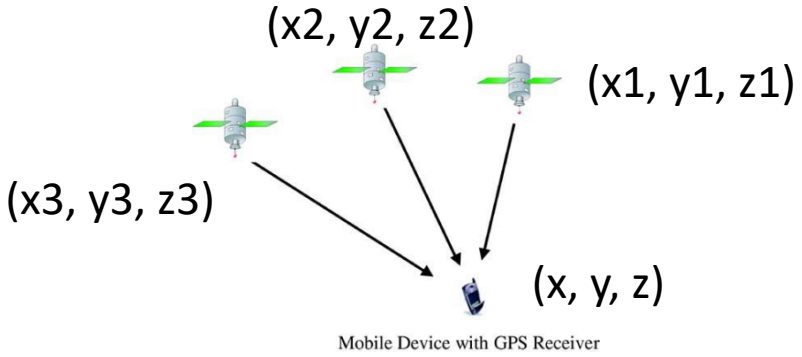
- Public applications:
  - Enterprise - Why does it always take so long to deliver to customer X?
  - Government - What is the traffic condition now from Shanghai to Suzhou
  - Public - How long before the next bus will arrive at this bus stop?
  - Security - location-based access control
  - Network routing - location-based routing

Location Acquisition

- Traditional ways
  - Satellite based - GPS/Galileo/BDS/Glonass
  - Network based - GMS/3G positioning systems
  - Mechanic methods - dead reckoning/inertial navigation
- New solutions
  - WLAN based positioning
  - RFID based positioning
  - Ultrasonic/sonar positioning
  - Infrared Position
  - Image based positioning
  - Environmental noise based positioning

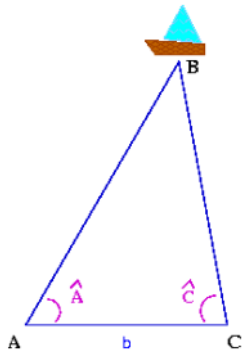
Satellite based Positioning

- GPS uses 24 to 32 satellites for positioning
  - Satellites broadcast positioning radio signals
  - The radio signal contains satellites' position and time
- Trilateration positioning method
  - Mobile device measures the signal propagation distance
  - Mobile device computes its position based on multiple measurements



Cellular Network based Positioning

- Cellular network makes use of base stations (BS) for cell phone positioning
  - BS are equipped with GPS for their positions
  - BS measure the radio signal of a cell phone
- Positioning method
  - Cell-ID
  - Trilateration
  - Triangulation

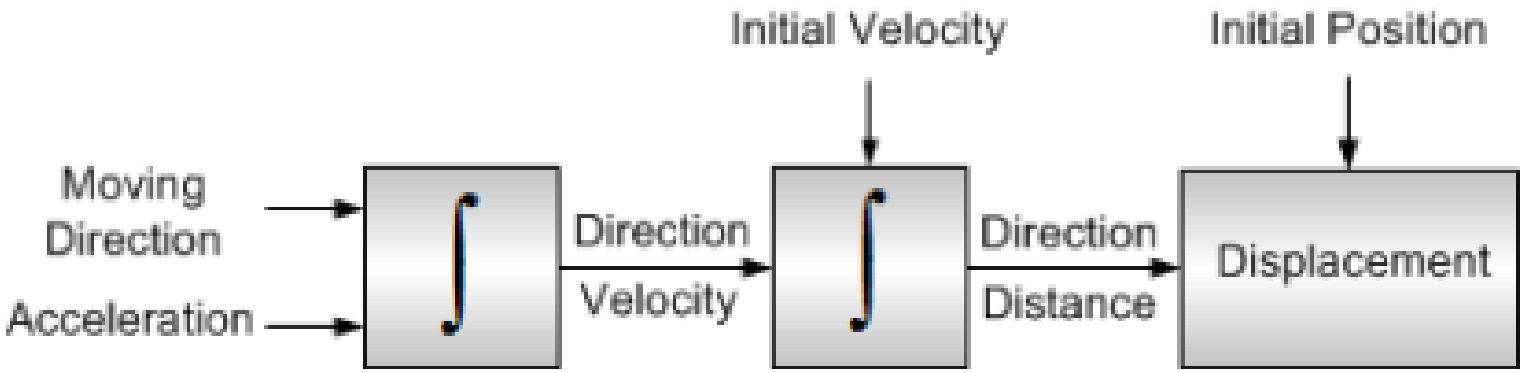


WLAN based Positioning

- Access points (AP) broadcast radio signals
  - Somehow like a satellite or a BS, but
  - Position of AP is unknown
  - AP cannot measure the radio signal of mobile devices
- A solution for Positioning
  - A geo-database of AP signal strength
  - Locate the mobile user by searching the database
  - Commonly known as the Fingerprint/Received signal strength method

Mechanic Positioning Methods

- user's current position can be estimated with
  - Its previous position
  - Its travelling distance during this period
  - Its travelling direction during this period

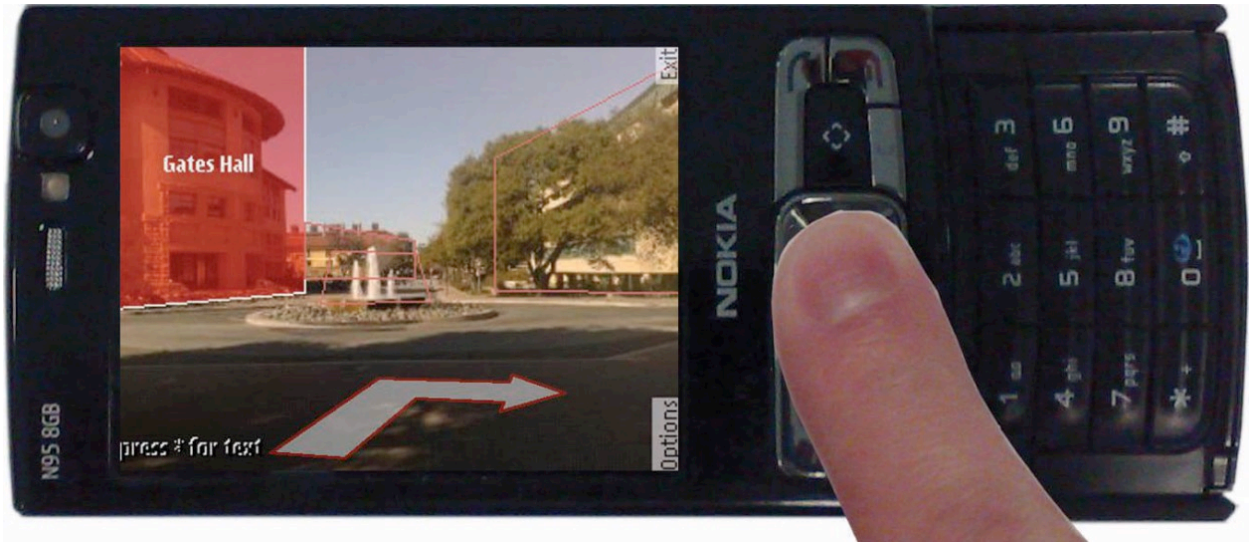


Augmented Reality

- Combining live direct view of a physical real-world environment with virtual CGI
  - Typically in real-time using the semantics of environmental elements
  - Identify digital “cues” (e.g. 2D barcode) and overlay with a digital image

Use of Augmented Reality

- Can be used to enhance the environment
- Provide details about the environment, by “projecting” labels
- or directions onto the street or building being viewed

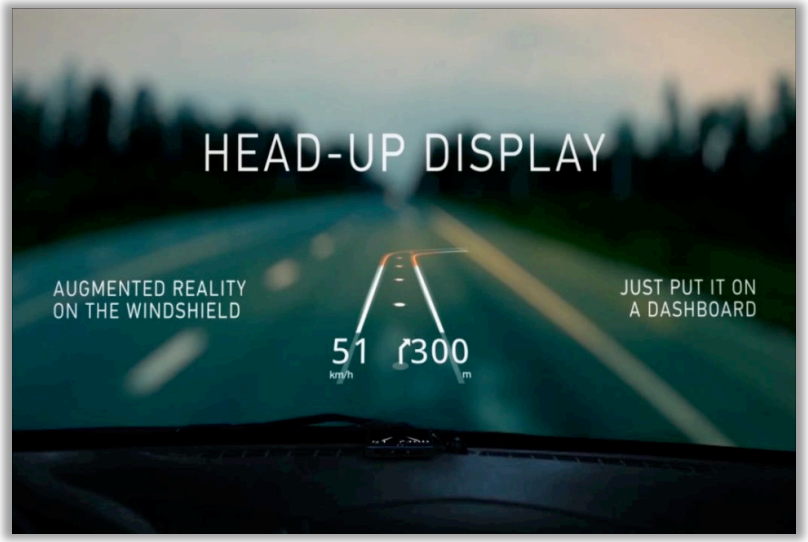


Use of Augmented Reality

- Can be used for entertainment
  - Project games into the real-world, by identifying cues to determine location or features
  - Create virtual figures

Use of Augmented Reality

- Can be used to display information without disturbing
  - Head-up display



Technological Challenges

- Image analysis is required to identify cues to overlay graphics
  - Positioning information required, to determine relative location of other artifacts that may be annotated
  - Live video is required to project the graphics onto