# Location & Context
# UI Design for Small Displays

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# Lectures & Exercises

| Lecture | Date | Topic |
|---|---|---|
| 1 | 12.1. | Mobile Device Platforms |
| 2 | 19.1. | Introduction to Mobile Interaction |
| 3 | 26.1. | Prototyping and Evaluation of Mobile Systems |
| 4 | 2.2. | Mobile Input & Output Technologies |
| 5 | 9.2. | Location & Context, UI Design for Small Displays |

| Exercise | Date | Topic |
|---|---|---|
| 0 | | Developing countries + Android-Eclipse |
| 1 | 10.1. | Recipe input |
| 2 | 17.1. | Touch input, gestures |
| 3 | 24.1. | Evaluation of mobile LMU Web portal |
| 4 | 31.1. | Location-based audio |

# Context

# Characteristics of Context

- Context
  - Where you are, who you are with, what resources are nearby
  - Information about the user, the user's environment, the device's context of use
- User's context changes rapidly when mobile
  - User interacts with many devices, people, objects, and places
- Context-aware applications
  - Capture and retrieve context information
  - Adapt to the user's context
  - Reduce need for explicit user input
  - Are better integrated with user's environment and activity

# Active Artifacts


- Determine activity where it occurs
- Add “self perception” to everyday things
- Communicate their own state
- The artifact digitally “supports” its own applications
- Example: MediaCup
  - http://mediacup.teco.edu
- Exercise: Assume MediaCup should be able to discriminate
  - Informal meeting
  - Presentation Coffee break
  - Working alone

  → What sensors? How to represent the situation?

# Defining Context

- Context-aware computing (Schilit and Theimer, 1994)

  Software that “adapts according to its location of use, the collection of nearby people and objects, as well as changes to those objects over time”

- Context (Dey, 2001)
  - “Context is any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves, and by extension, the environment the user and applications are embedded in.”

# Context Sources

- Current location
- Location history
- Orientation
- Speed
- Time of day
- Day of week
- Illumination
- Noise level
- Temperature
- Network availability
- Network bandwidth
- Remaining battery life
- Device movements
- Dialogue history
- User's activity & schedule
- User's mood
- Group constellation
- Number of people around

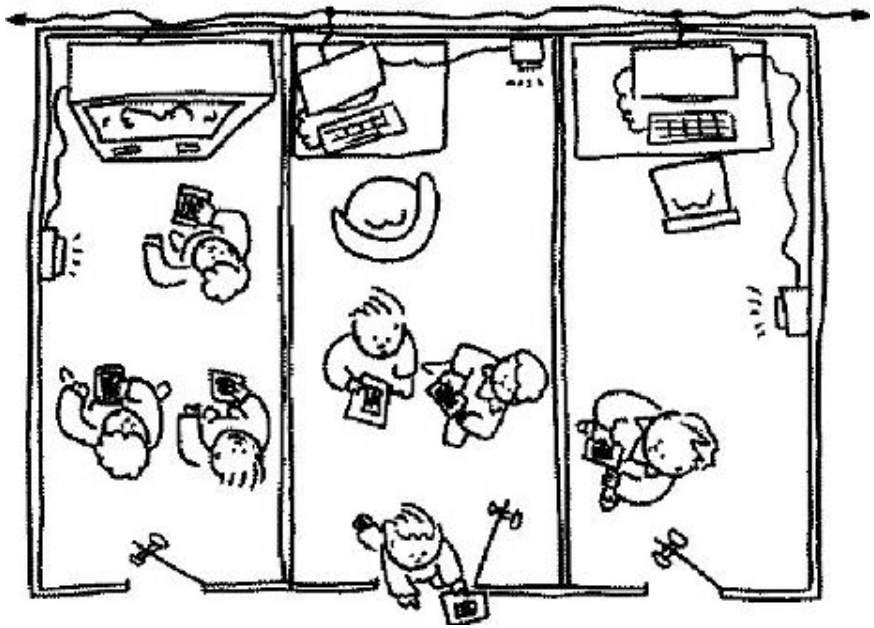
# Location and Context

- Location is an important part of the user's context
- Locations have a context
  - Noise level and its fluctuations
  - Light level and its fluctuations
  - Number of people in the space
  - Relationship between people present
  - Social protocol at that location
  - Activity for which the location is designed

# Techniques in Context-Aware Computing

(Schilit, Adams, Want: Context-Aware Computing Applications. 1994)

- Proximate selection
  - E.g., list nearest printer first
- Automatic contextual reconfiguration
  - E.g., share nearby electronic whiteboard automatically
- Contextual information and commands
  - Commands with different meanings in different contexts
  - Command only in certain contexts
- Context-triggered actions
  - Condition-action rules



Source: Schilit et al. 1994

# Context-Triggered Actions

- Simple if-then-rules, similar to Unix CRON-Demon:
  - Coffee Kitchen arriving „play -v 50 /sounds/rooster.au
  - Schilit * attention „emacs -display $NEARESTHOST:0.0“
- Contextual reminders: information is displayed under certain conditions. Example:

$DATE=„after April 15“
AND $TIME=„after 10“
AND $room=„35-2-200“
AND $WITH-USER=Adams“
AND Color($DISPLAY)=„true“

# Difficult Problems in Context-Aware Systems

- How to abstract relevant (higher level) context from low level sensor data
  - How do derive user's intent and situation?
  - Sensors → features → context → intent/situation
  - How to deal with uncertainty in context recognition?
- How to model and exchange context data?
  - Going beyond basic sensor data mining requires AI techniques, knowledge representation (ontologies, taxonomies)
- How to apply the obtained context information
  - Implicit vs. explicit control of systems
- Intelligibility
  - Helping the user to understand system actions
  - Proactivity vs. losing control

# Usability Risks for Mobile Context-Aware Applications (Dey, Häkkilä, 2006)

- Uncertainty in context recognition
- Information overflow
- Lack of user control
- Application complexity
- Privacy violations
- Subjective understanding of context attributes
- Lack of common agreed ontologies
- Imbalance between automatic and user-initiated actions
- Poor interoperability

Dey, Häkkilä: Context-Awareness and Mobile Devices. Handbook of Research on User Interface Design and Evaluation for Mobile Technology. 2008.

# Design Guidelines for Mobile Context-Aware Applications (Häkkilä, Mäntyjärvi, 2006)

- Select appropriate level of automation
  - Depending on level of uncertainty
- Ensure user control
- Avoid unnecessary interruptions
  - Intrusive, distract, but can have high value
- Avoid information overflow
- Appropriate visibility level of system status
- Personalization for individual needs
- Secure user's privacy
- Take into account the impact of social context

Häkkilä, Mäntyjärvi: Design Guidelines for Context-Aware Mobile Applications. Proceedings of Mobility'06, ACM Press, 2006.

# Location

# Aspects of Location Information

- Position vs. place
  - 52N 13E vs. T-Labs building
- Absolute vs. relative
  - 52N 13E vs. 10 km west of where I am
- Representation of uncertainty
  - A few km vs. room level vs. a few cm
- Indoor vs. outdoor
  - Elevation / floor number difficult
- Privacy model
  - Self-positioning vs. infrastructure-based

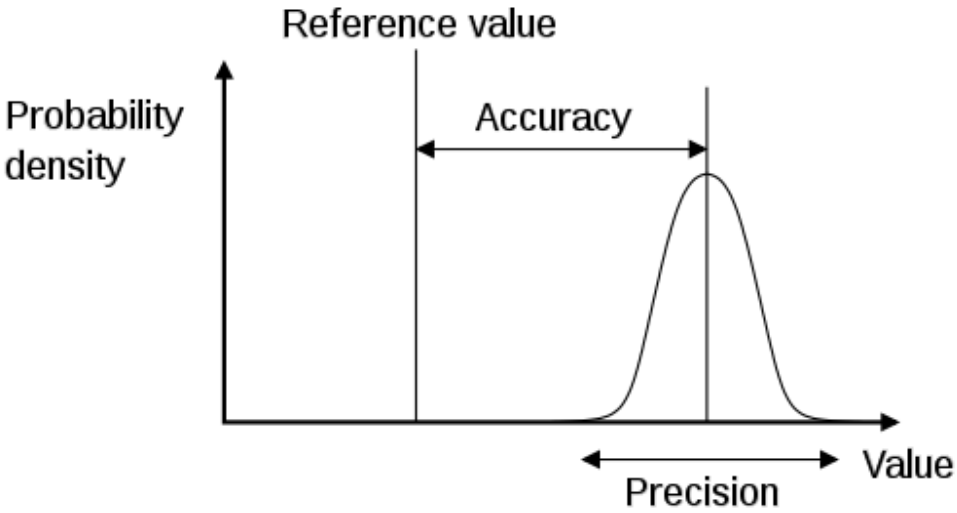

Blue area exposes uncertainty

# Some Location Technologies


- GPS
- Wi-Fi access points
- GSM cell
- Ultrasound (time of flight) + radio signal
- Camera: Visual recognition
- Floor pressure
- Signal strength
- Laser range-finding
- Proximity and physical contact (RFID, NFC)

# Challenges of Deriving Location

- Uncertainty
  - Accuracy, precision
- Cost
  - Money, energy
- Responsiveness
  - Time to result
- Ubiquity
  - Coverage, indoors, outdoors



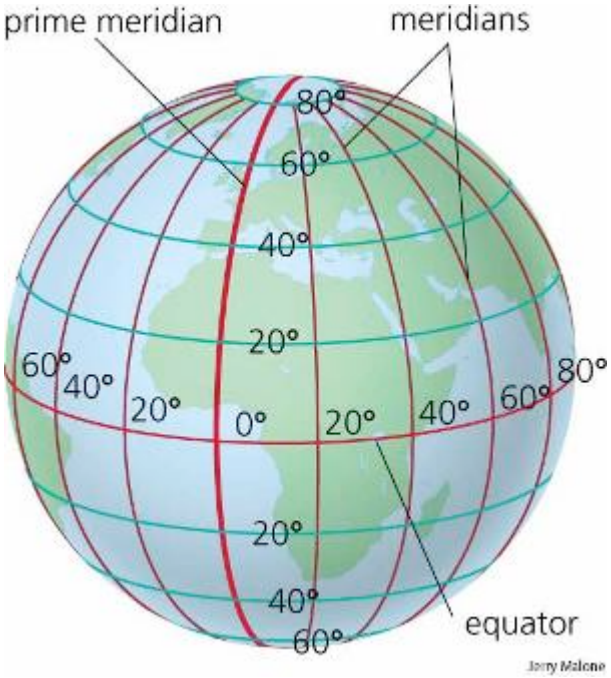

High accuracy, low precision

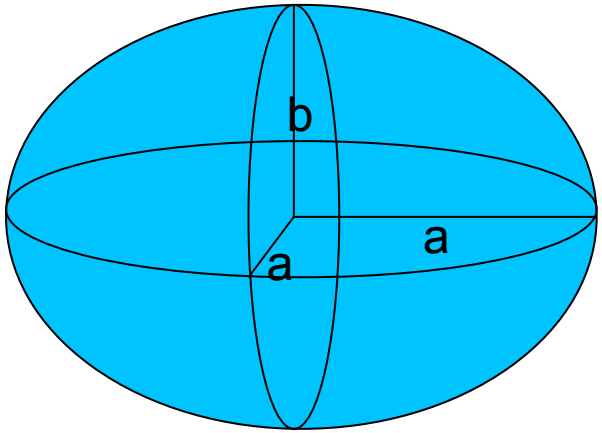
Low accuracy, high precision

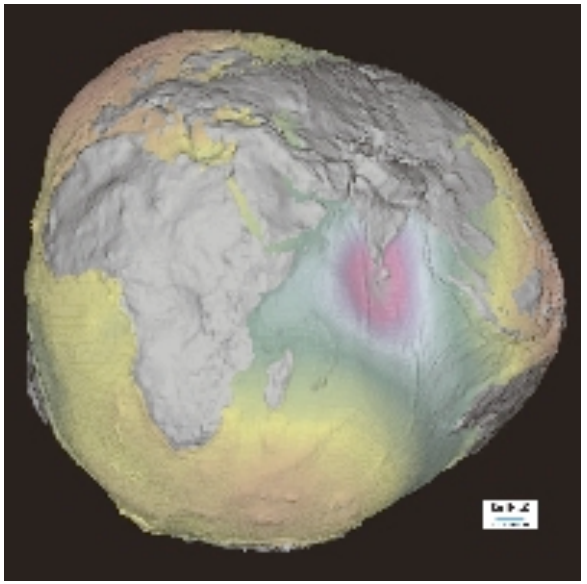
# Describing Location

# Location Reference System: Coordinates ≠ Coordinates

- Treat the earth as a sphere, ellipsoid or geoid

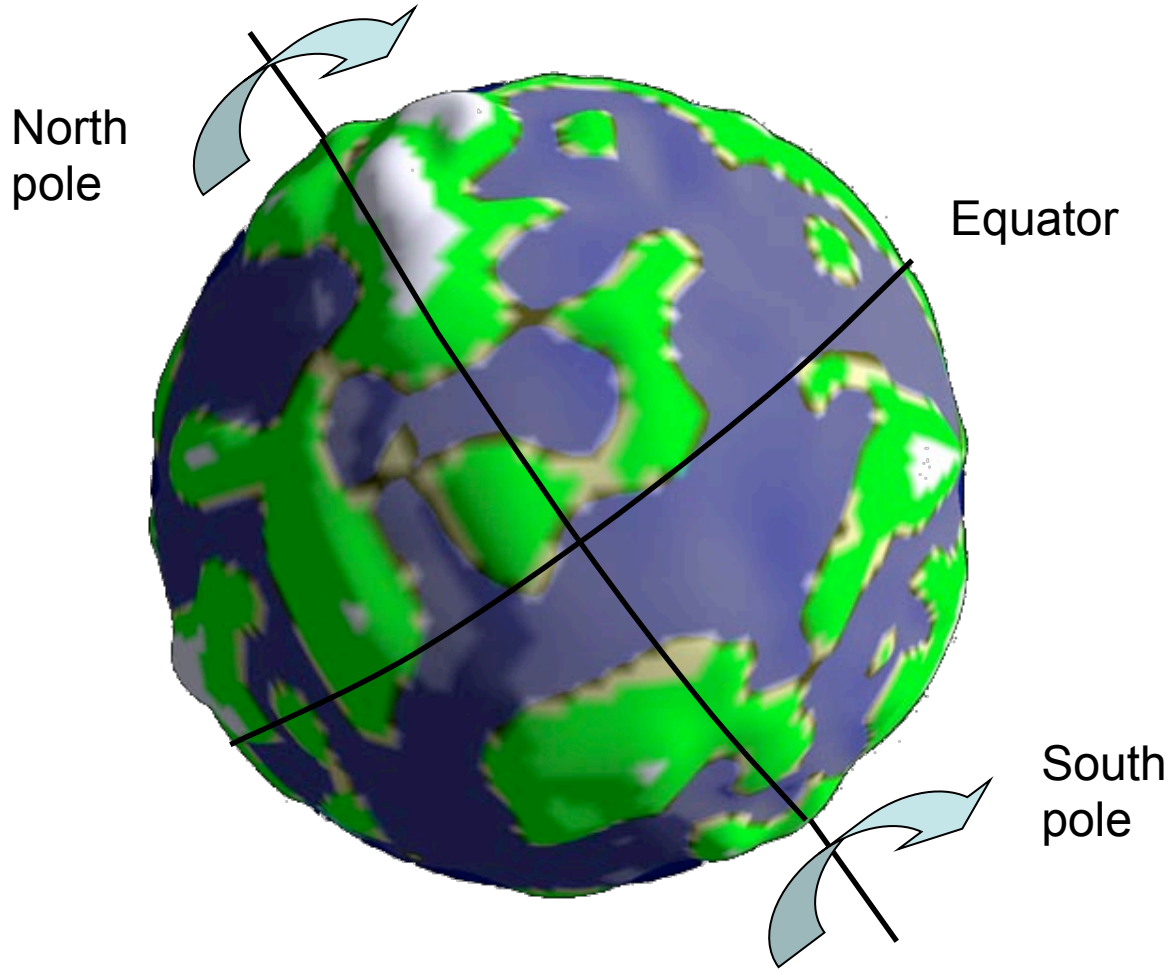


# Global Reference System?

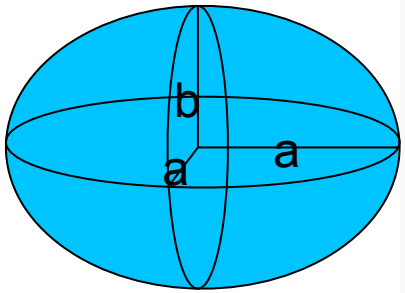
- How to denote locations on a sphere?



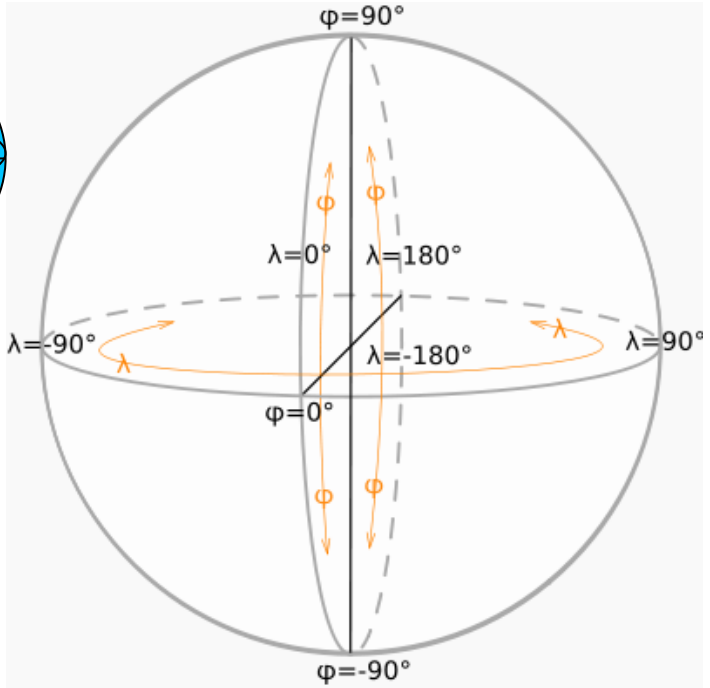
# WGS 84 – A Global Reference System

- The World Geodetic System defines a reference frame for the earth, for use in geodesy and navigation.

- Using a special ellipsoid: WGS 84
  - a= 6,378,137.000 m
  - b= 6,356,752.314 m
  - Inverse flattening:
    f = 298.257 := (a-b) / a



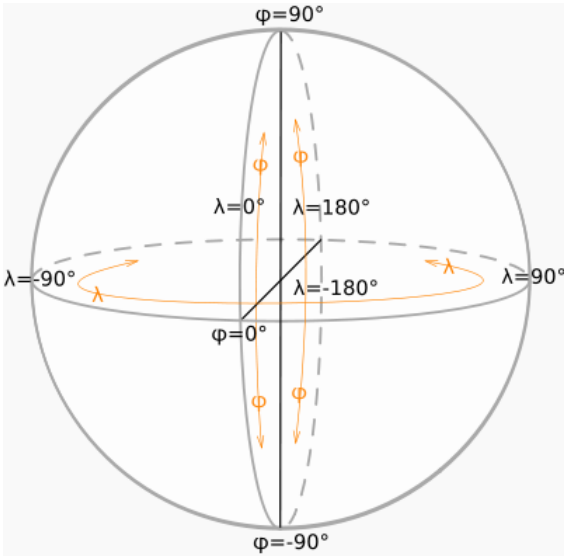

- Geocentric and globally consistent within ±1 m
  - Latitudes, longitudes, altitudes

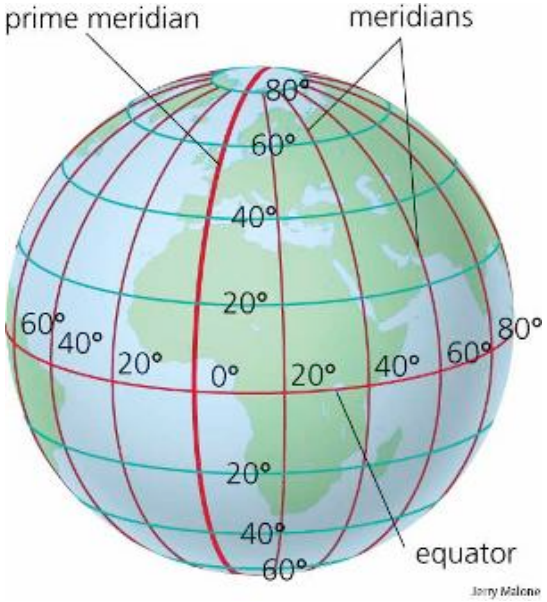


# WGS 84 – A Global Reference System

Laser projected from observatory marking Prime Meridian line

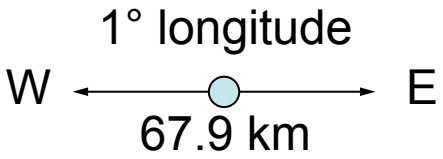
- Longitudes
  - λ = 0°: 102.5m east of the Greenwich Prime Meridian (Greenwich Royal Observatory)
    - 1675 King Charles II charged Astronomer Royal to "the rectifying of the tables of the motions of the heavens, and the places of the fixed stars, so as to find out the so much desired longitude of places for the perfecting of the art of navigation"
  - λ > 0°: east
  - λ < 0°: west
- Latitudes
  - φ = 0°: equator
  - φ = 90°: north pole
  - φ = -90°: south pole

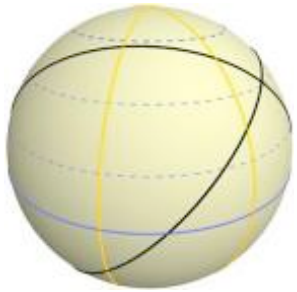


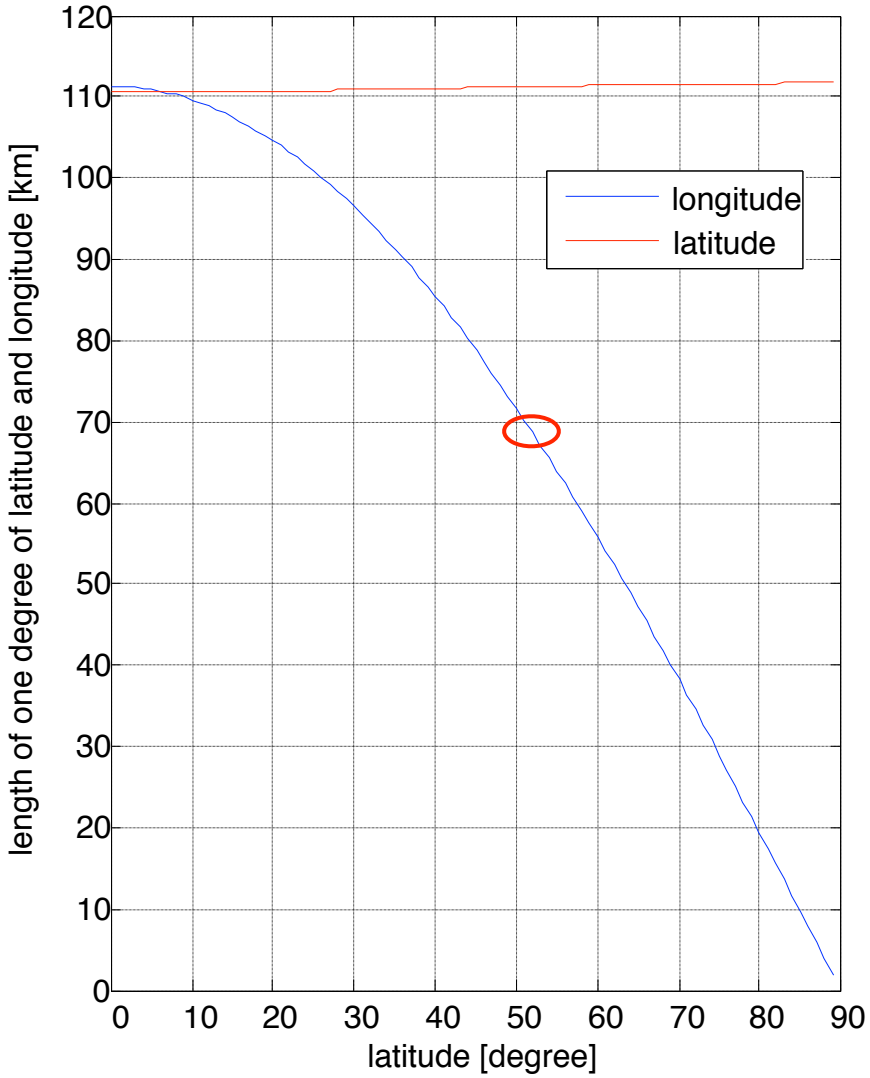
# Length of 1° Longitude in Meters

- At equator (lat. = 0°)
  - 1° lon. = 1/360 of the length of the equator = 111.3 km
- At North Pole (lat. = 90°)
  - 1° lon. = 0 km
- At T-Labs (lat. = 52.513°)
  - 1° lon. = 67.9 km



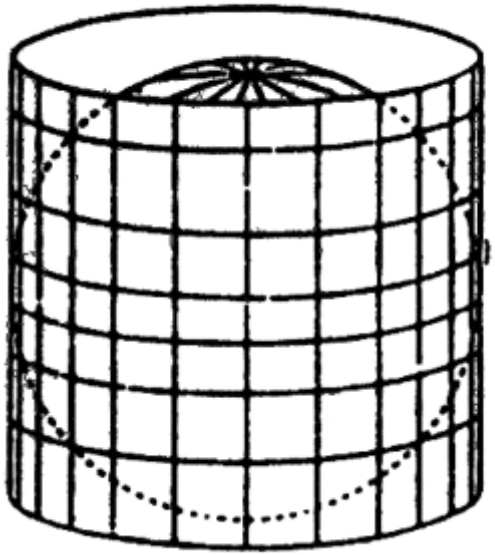



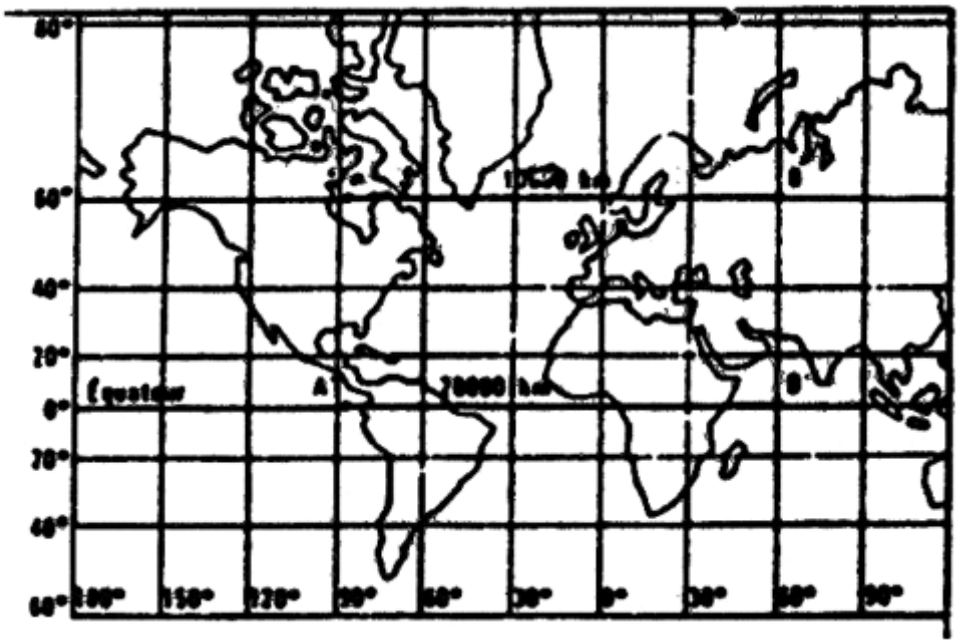
- Length of 1° of latitude slightly varies with latitude
  - Earth modeled as ellipsoid



# Map Projections

- How to draw a 3D sphere on a 2D map?
- Many possibilities, all involve distortions
- Mercator projection: cylindrical projection
  - Standard for nautical navigation, used by GoogleMaps





# Google Maps Zoom Levels

- Zoom level = 0
  - Equator length = 256 pixels
    = 2π * 6378137 m
  - 1 pixel = 156.5 km
- Zoom level = i
  - Equator length = 256 * $2^i$ pixels
    = 2π * 6378137 m
  - 1 pixel = 2π * 6378.137 / (256 * $2^i$) km
- Zoom level = 19
  - 1 pixel = 2π * 6378.137 / (256 * $2^{19}$) km
    ≈ 30 cm

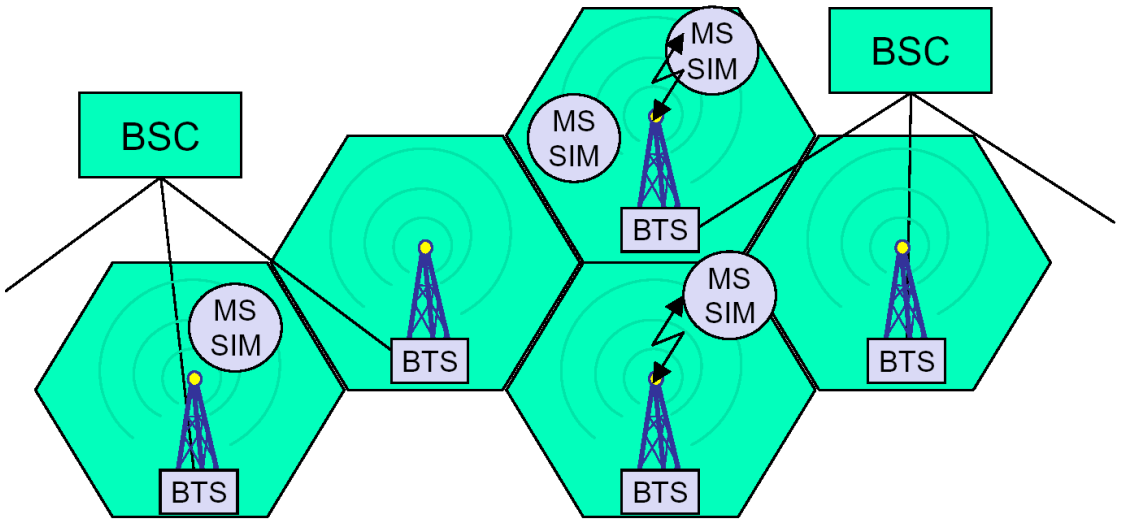
zoom level 0
equator = 256 pixels
= 2π * 6378137 m


zoom level 7
equator = 32768 pixels
1 pixel = 1.2 km

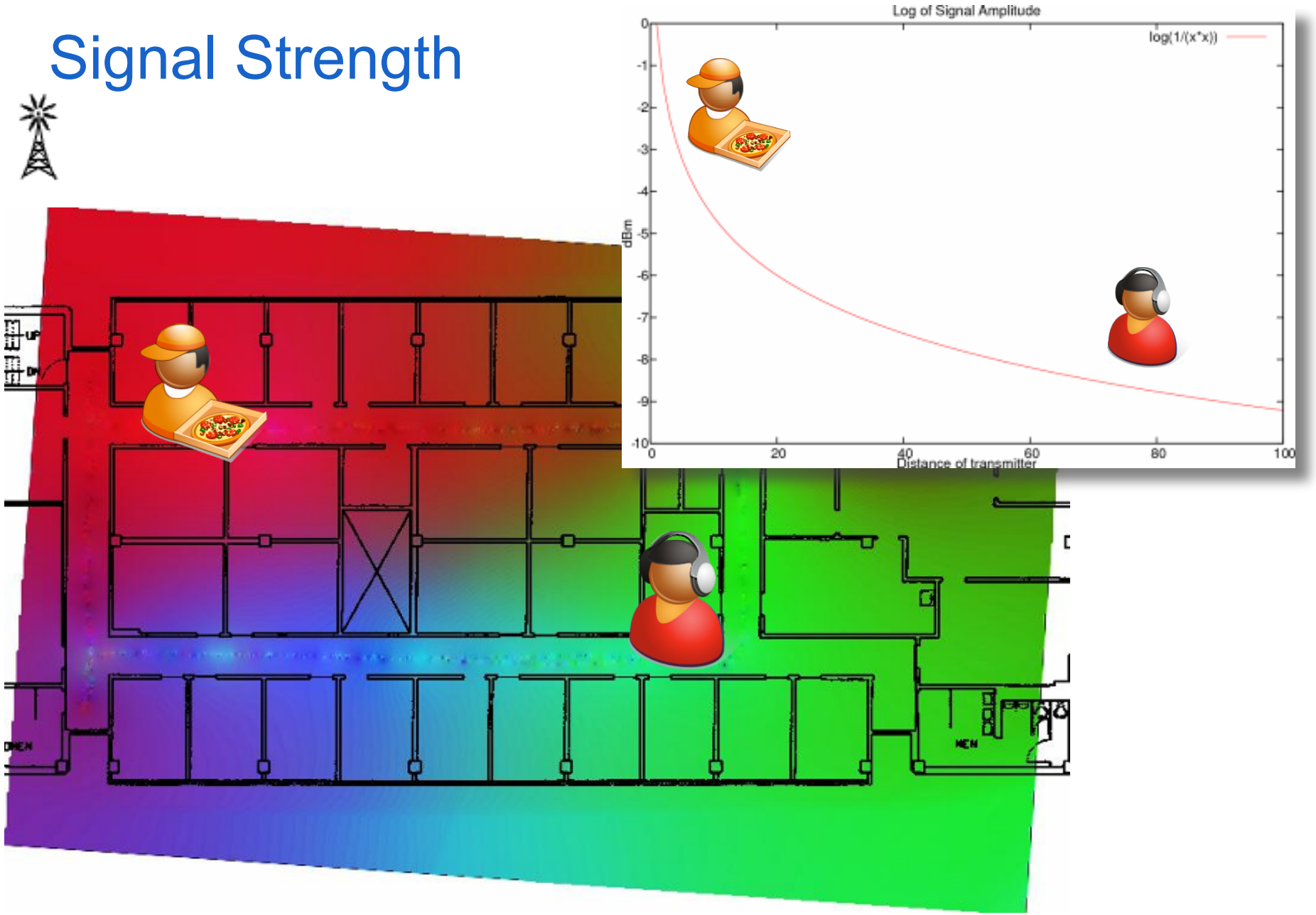
# Deriving Location

# Cell-based Positioning

- Basic GSM-based positioning
  - Cell-ID: 300m (city) to 20km (rural areas)
- More precise GSM-based positioning with
  - Sectored cells (angle of arrival)
  - Multiple base stations (time of arrival, signal strength)
- Only Cell-ID positioning always provided

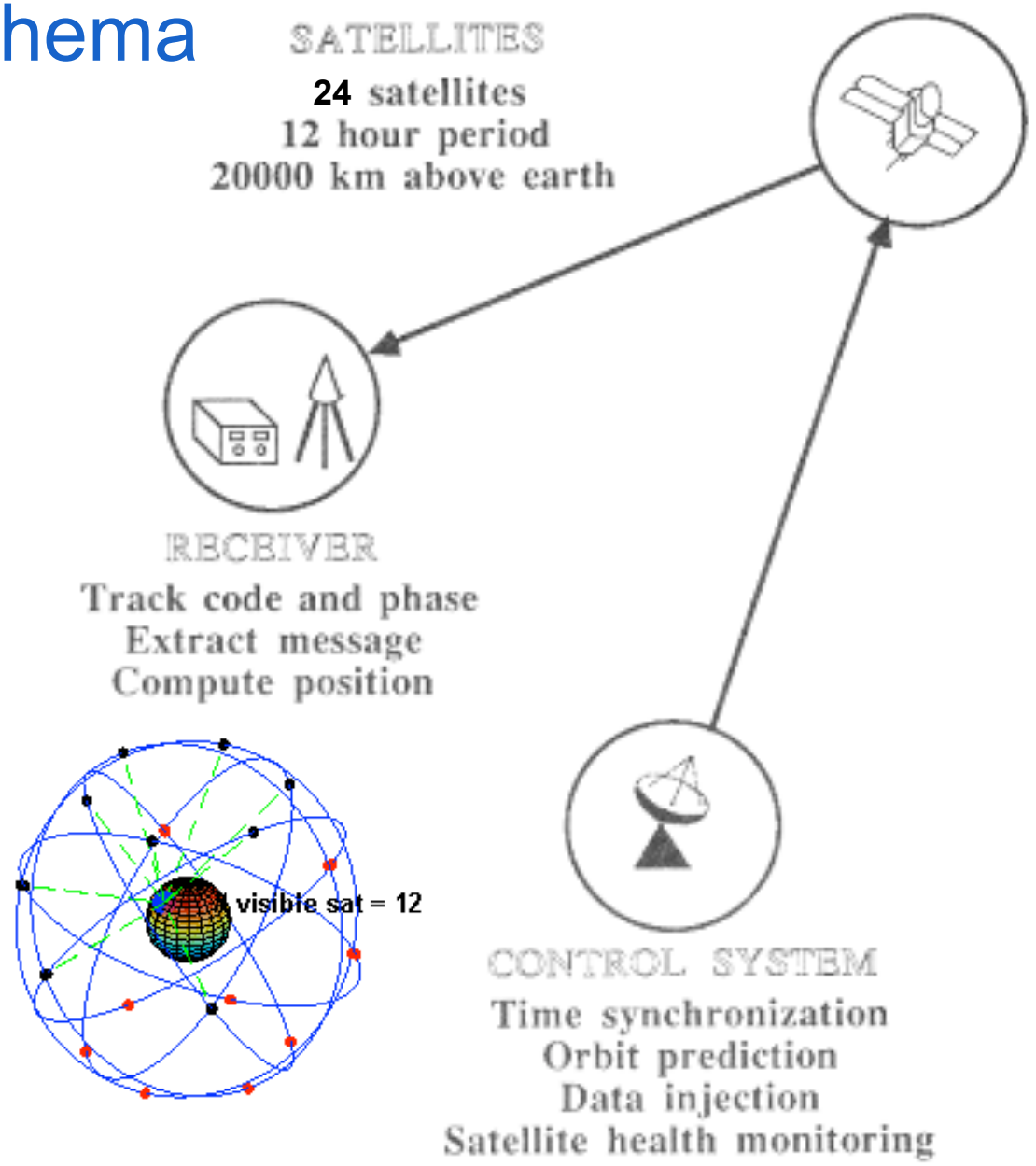


# Signal Strength

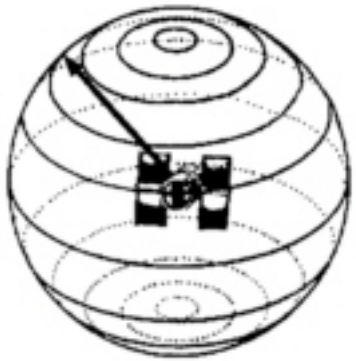


# GPS: System Schema

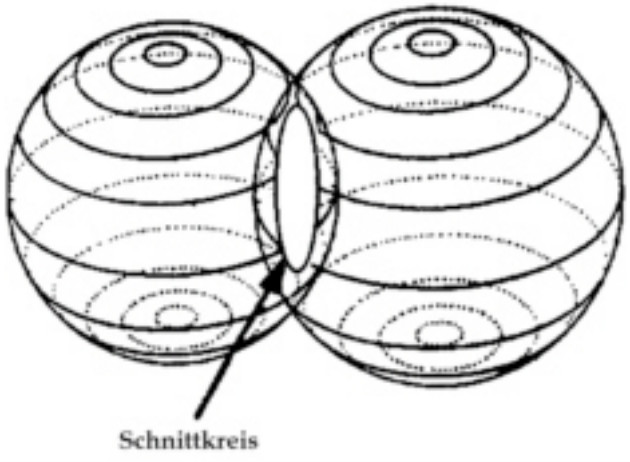
- Components
  - Satellites
  - Control system
  - Receiver
- 24 Satellites
  - 20000 km
  - 2 times around the world a day
- Maintenance cost
  - 750M$ a year



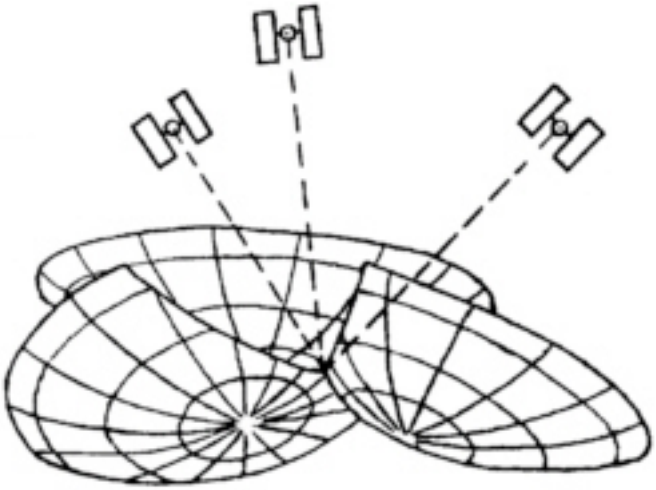
# GPS: Deriving Location



one satellite



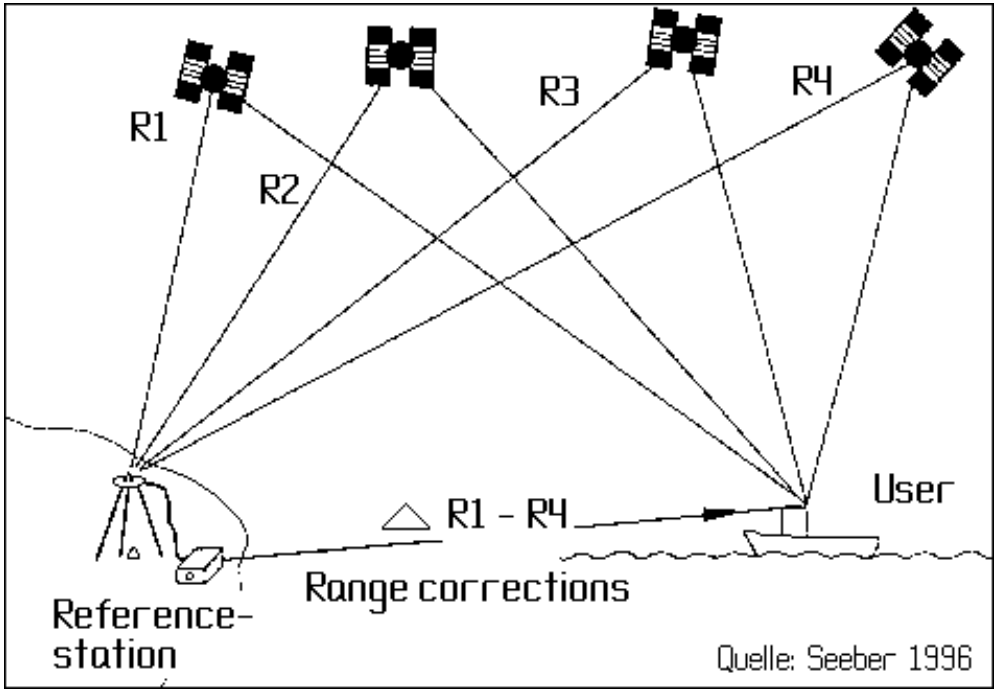

two satellites



three satellites

# GPS: Differential GPS

- Enhancement of precision by using a correct reference signal (Differential GPS)
- Need to know the position of a receiver that sends the difference between actual and measured position to the mobile device
- Problem: Delay of correction signal



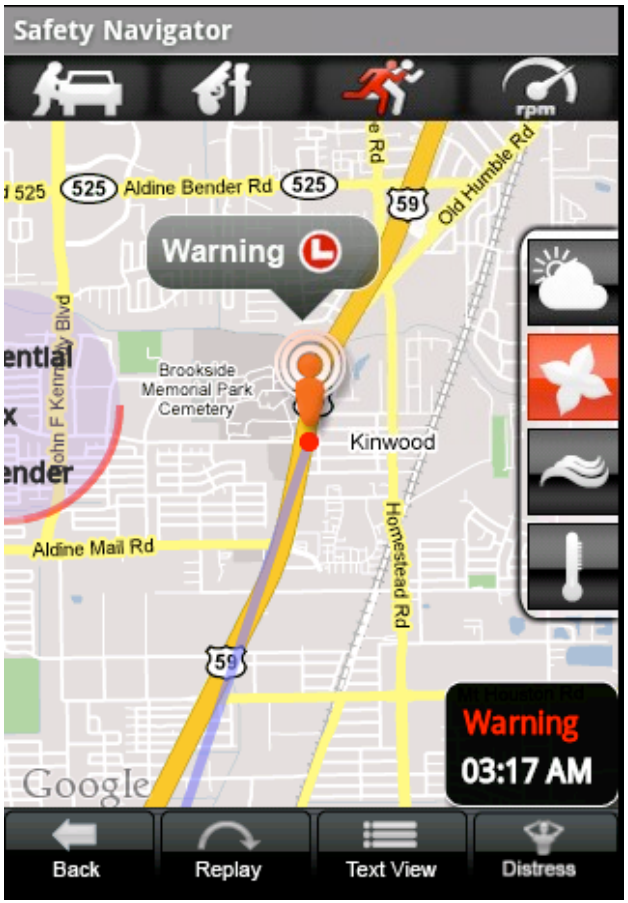
# Location-Based Services and Applications

# Layar “Reality Browser”

- Position + orientation
  - GPS, accelerometer, magnetometer
- Show POIs as overlays on viewfinder image
- Platform allows inserting new layers and POIs
- Layers
  - Real estate
  - Transportation
  - Tours / Guides
  - Eating & Drinking
- http://layar.com/

# iSafe – Personal Safety Application

- Informs you about possible dangers in your current location





http://www.freefamilywatch.com/demo.html

# Remember The Milk

- Organize your tasks by location


**Locate your tasks.**
Use the map to see where your tasks are located in the real world. See what's nearby or on your way, and plan the best way to get things done.


http://www.rememberthemilk.com

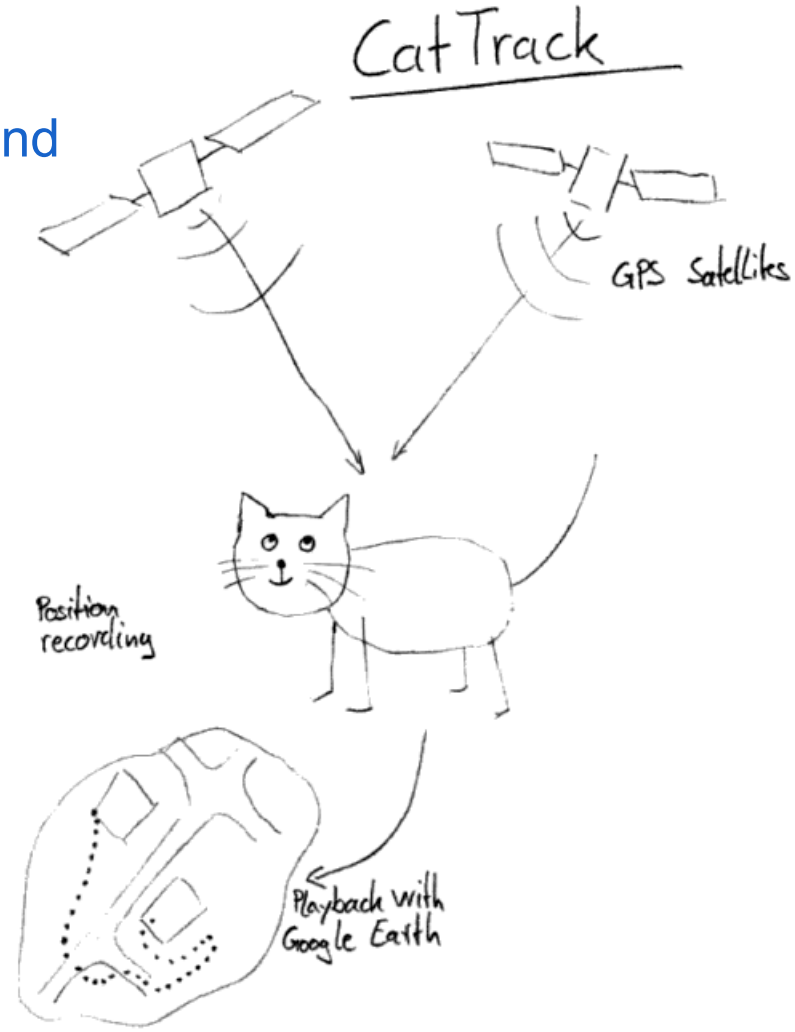
# REXplorer Location-Based Game (2005+)

- Explore the ancient Regensburg and interact with historical characters through gestures
- http://www.rex-regensburg.de/stadtspiel/rexplorer
- http://hci.rwth-aachen.de/REXplorer

# Mr. Lee GPS Tracking for Cats

- GPS receiver and camera
  - Know where your cat strolled around
  - Generate cat photo tours






http://www.mr-lee-catcam.de/index.htm

# UI Design for Small Displays

# Web Pages Don’t fit on Small Screens

# Web Pages Don’t fit on Small Screens

- Solution approaches
  - Device-specific authoring
  - Automatic re-authoring
  - Client-side navigation
- Double tap to zoom into region or text column
  - Uses HTML DOM model

# Overview + Detail

- Show details around cursor region
- But...
  - Detail region takes up valuable screen space
  - Overview region not readable
  - How should user know what to highlight?

# Browsing Web Content

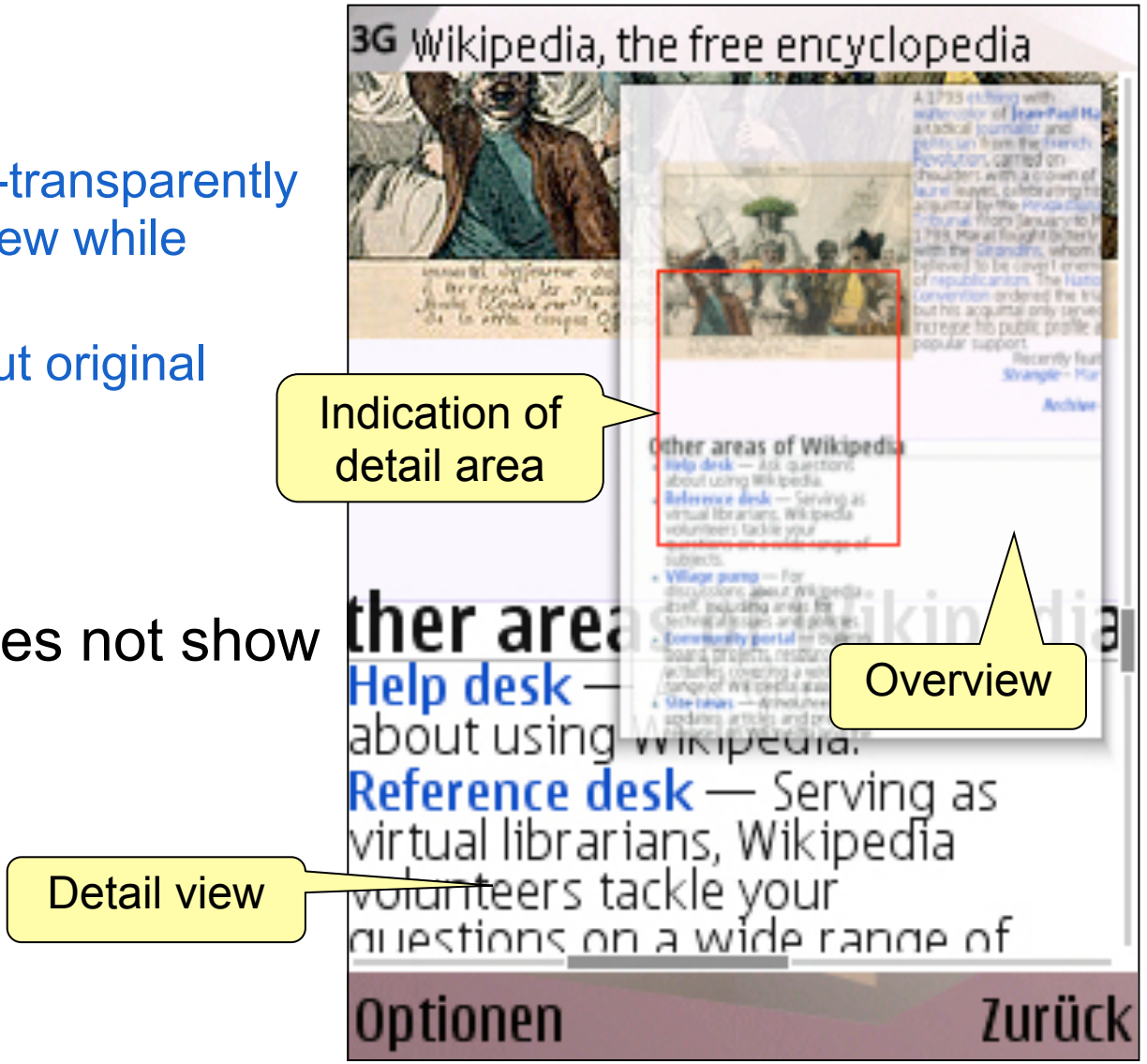
- Reorganize content in narrow vertical strip
  - Avoids horizontal scrolling
- 1-D browsing
- Narrow layout
  - Width = display width
  - Compact layout
  - Original layout destroyed
  - Little overview



# Context in Focus Display

- Nokia MiniMap
  - Overview is semi-transparently shown in detail view while scrolling
  - Content scaled but original layout preserved

- Even overview does not show whole page

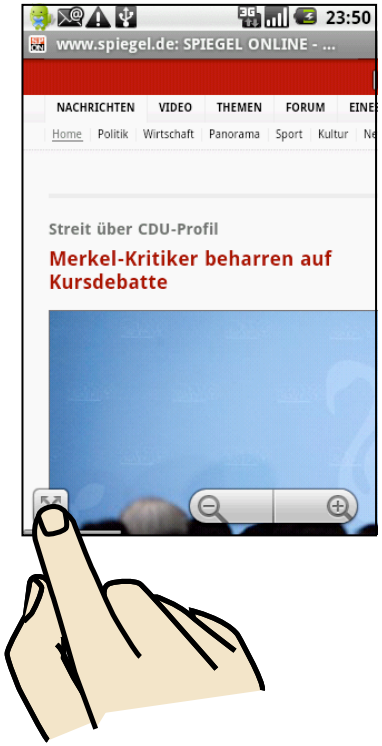


# Nokia Symbian Browser

- Overview embedded in detail view
- Semi transparent detail view
- Site-specific adaptations

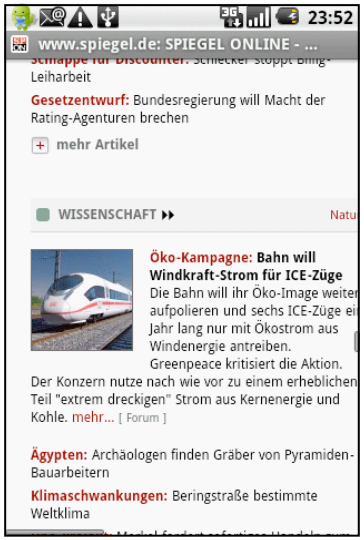



# Android Browser







# Locating Off-Screen Objects

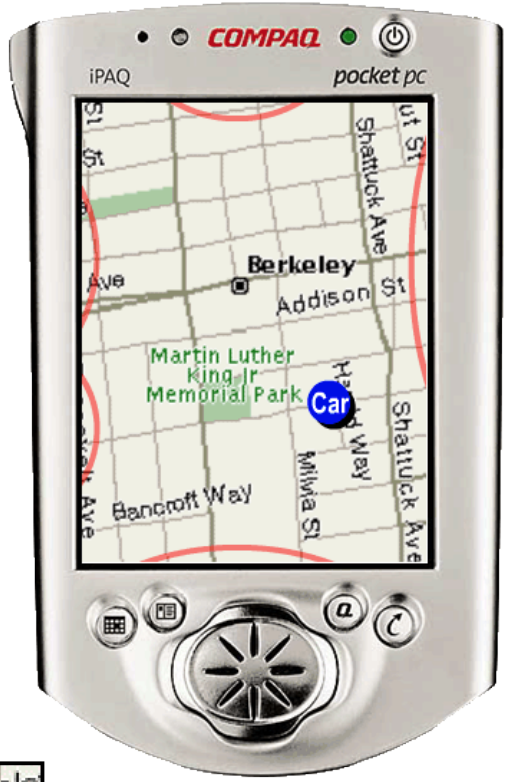
# Halo (Baudisch & Rosenholtz, 2003)


Baudisch, Rosenholtz: Halo: A Technique for Visualizing Off-Screen Locations. CHI 2003.

Source: Patrick Baudisch

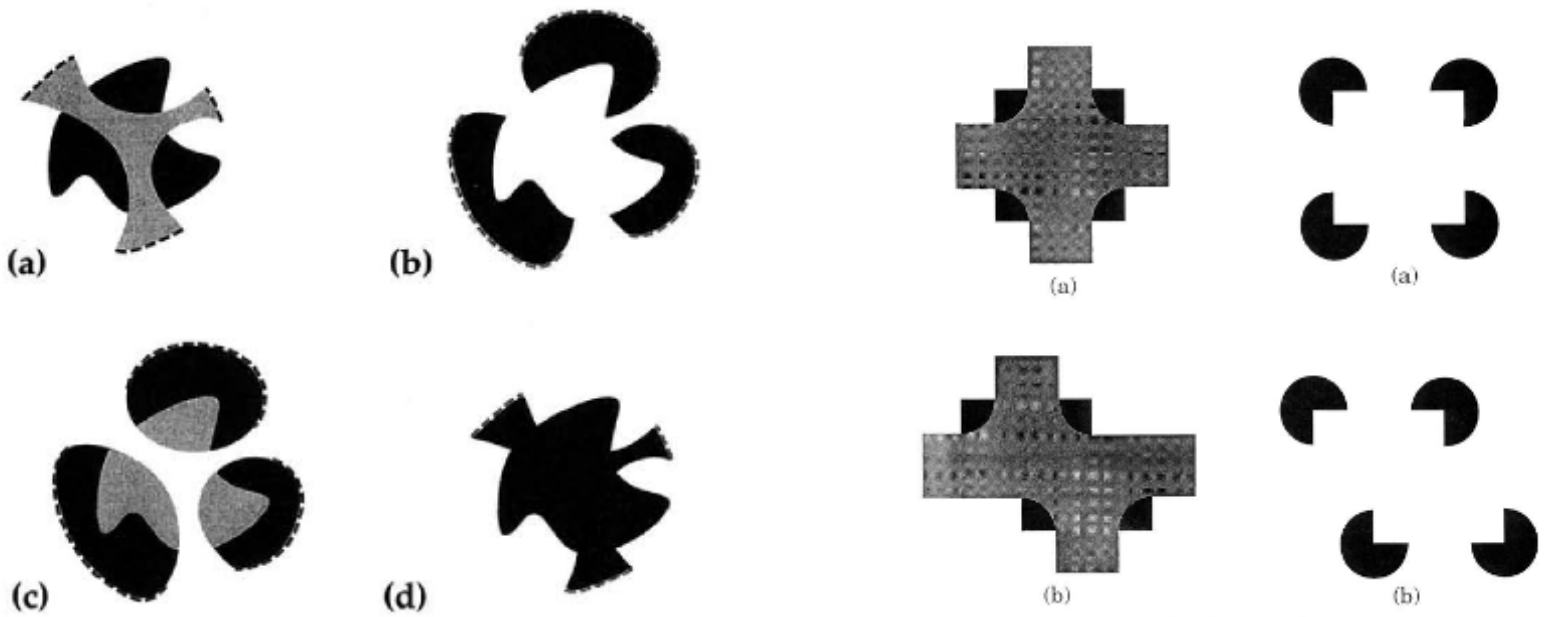
# Streetlamp Metaphor

- Aura visible from distance
- Aura is round
- Overlapping auras aggregate
- Fading of aura indicates distance

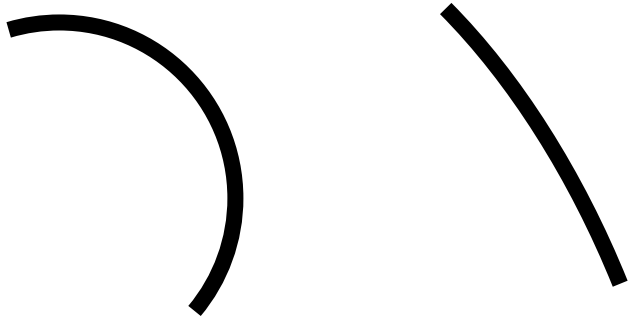



Source: Patrick Baudisch

# Gestalt Laws: Perceptual Completion




Shipley and Kellman 1992



Source: Patrick Baudisch

# User Study: Halos vs. Arrows


arc/arrow fading off

same selectable size

legend

halo ring

distance from display border

Source: Patrick Baudisch

# 1. Locate Task


click at expected location of off-screen targets

Source: Patrick Baudisch

# 2. Closest Task


click arrow/arc or off-screen location closest to car

Source: Patrick Baudisch

# 3. Traverse Task


click on all targets in order, so as to form the shortest delivery path, beginning at the car

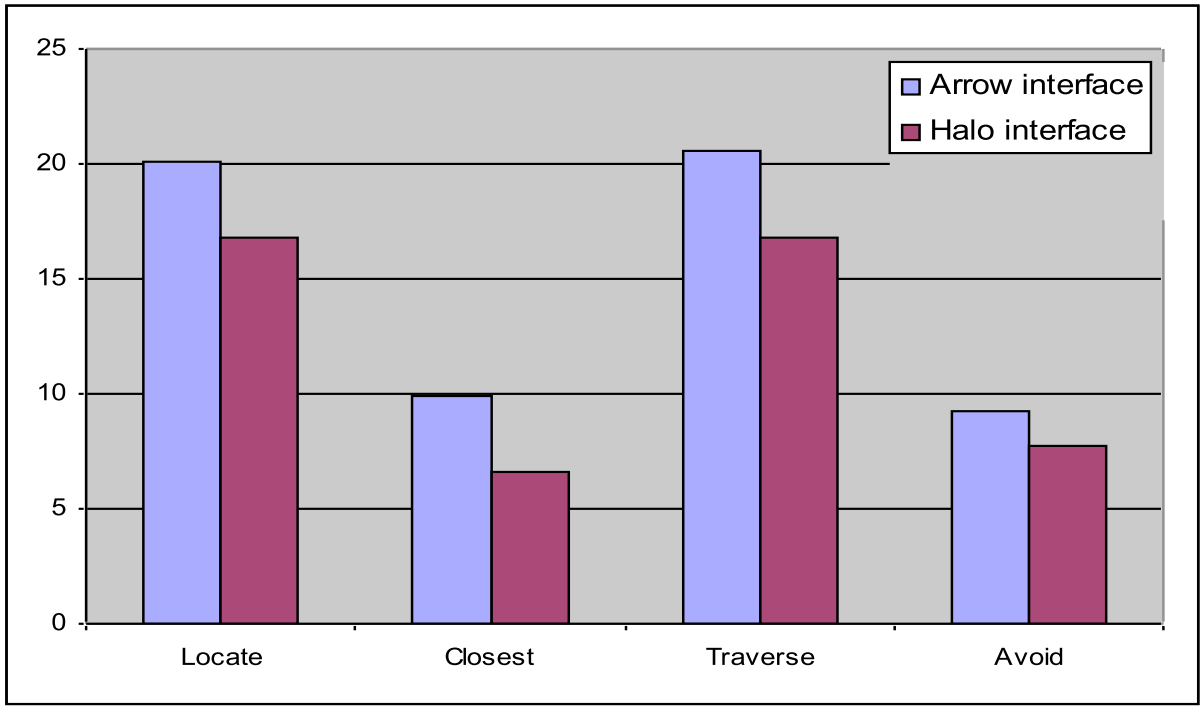
Source: Patrick Baudisch

# 4. Avoidance Task


click on hospital farthest away from traffic jams

Source: Patrick Baudisch

# Task Completion Time

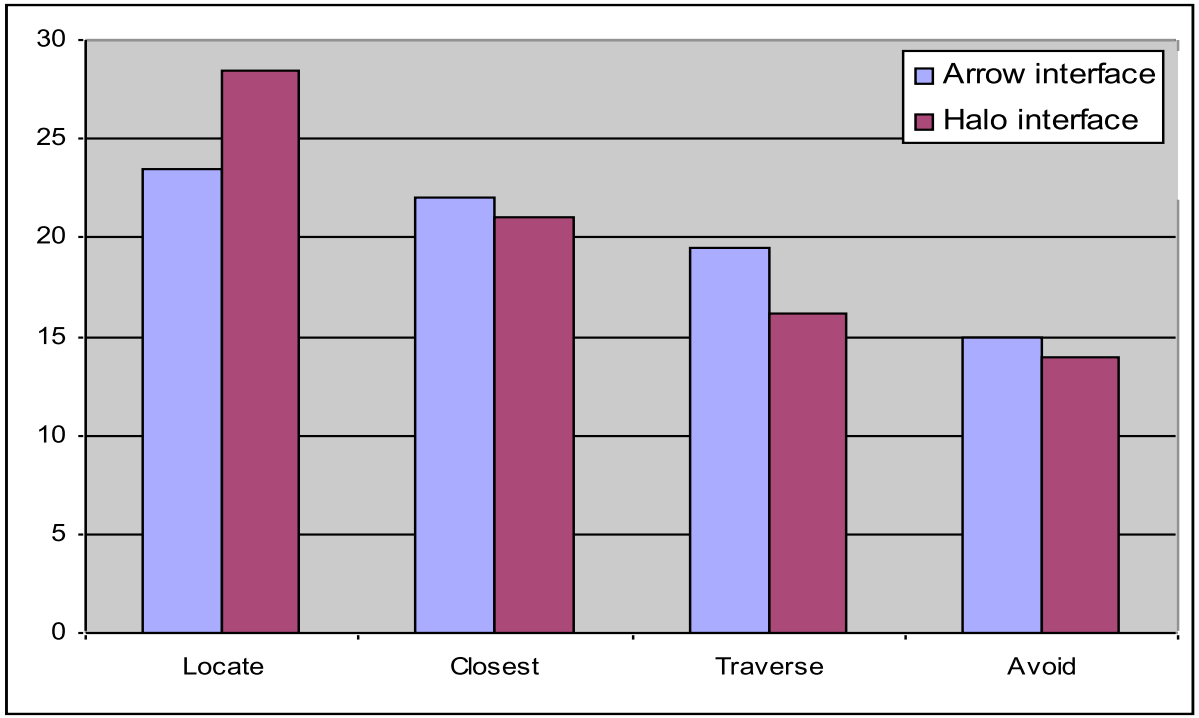


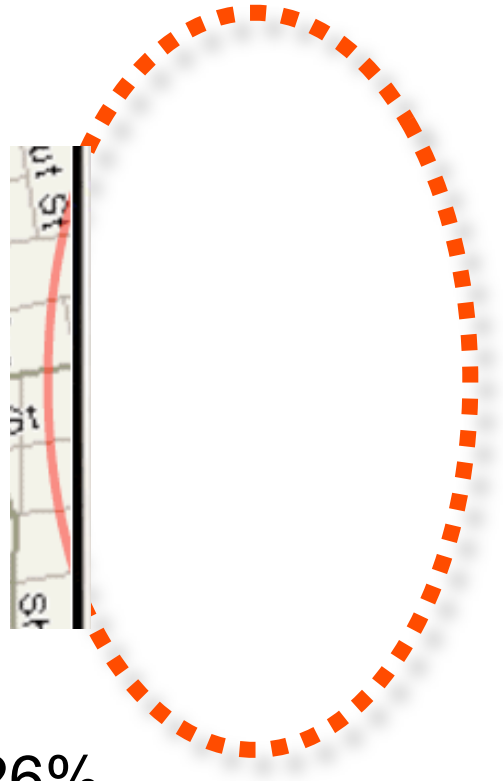

| Task | Arrow interface | Halo interface |
|---|---|---|
| Locate | 20.1 (7.3) | 16.8 (6.7) |
| Closest | 9.9 (10.1) | 6.6 (5.3) |
| Traverse | 20.6 (14.1) | 16.8 (8.7) |
| Avoid | 9.2 (4.7) | 7.7 (5.8) |

Source: Patrick Baudisch

# Error Rate

| Task | Arrow interface | Halo interface |
|---|---|---|
| Locate | 23.5 pixels (21.6) | 28.4 pixels (33.8) |
| Closest | 22% (42%) | 21% (41%) |
| Traverse | 97.4 pixels (94.7) | 81.0 pixels (96.7) |
| Avoid | 15% (35%) | 14% (34%) |



- Participants underestimated distances by 26%
- Participants saw ovals
- To compensate: width += 35%

Source: Patrick Baudisch

# Subjective Preference


Source: Patrick Baudisch

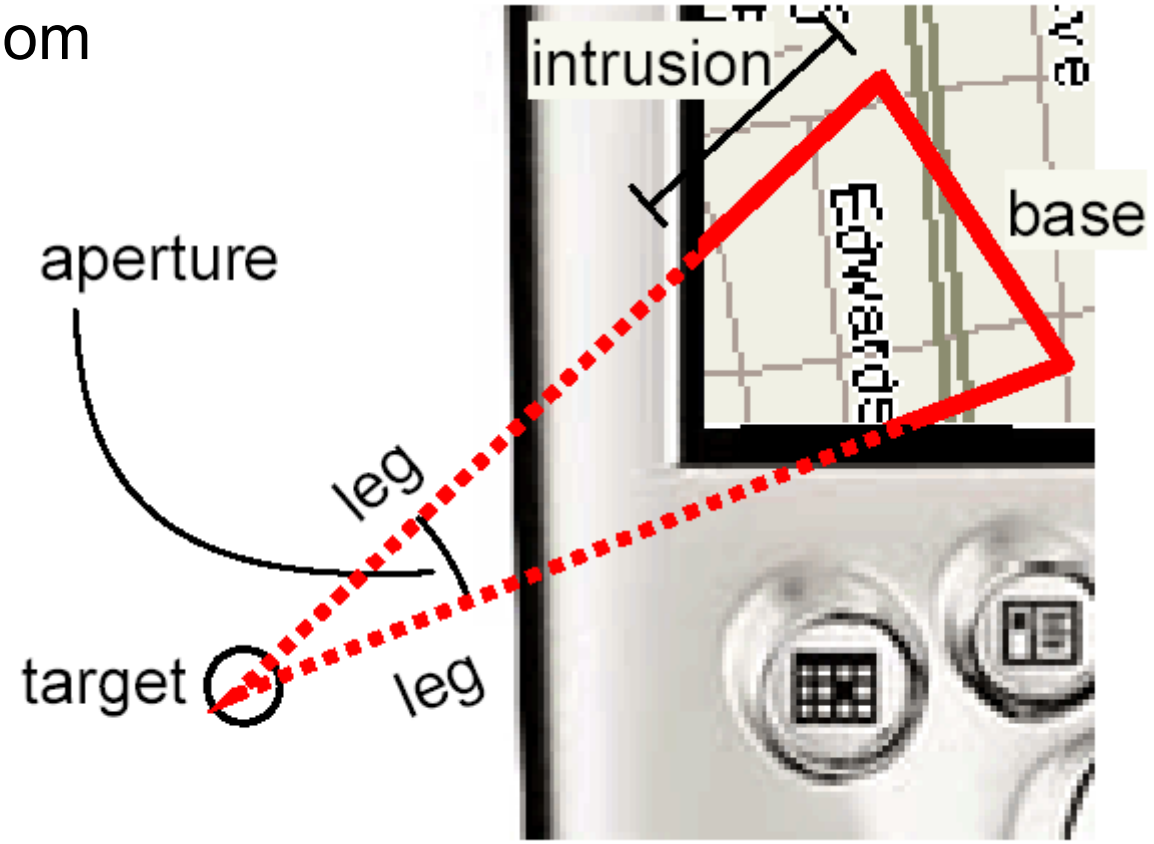
# Limitation of Halo: Clutter

- Clutter from overlapping or large number of halos
- Wedge: Isosceles triangles
  - Legs point towards target
  - Rotation, aperture
- No overlap
  - Layout algorithm adapts rotation and aperture


Gustafson, Baudisch, Gutwin, Irani: Wedge: Clutter-Free Visualization of Off-Screen Locations. CHI 2008.

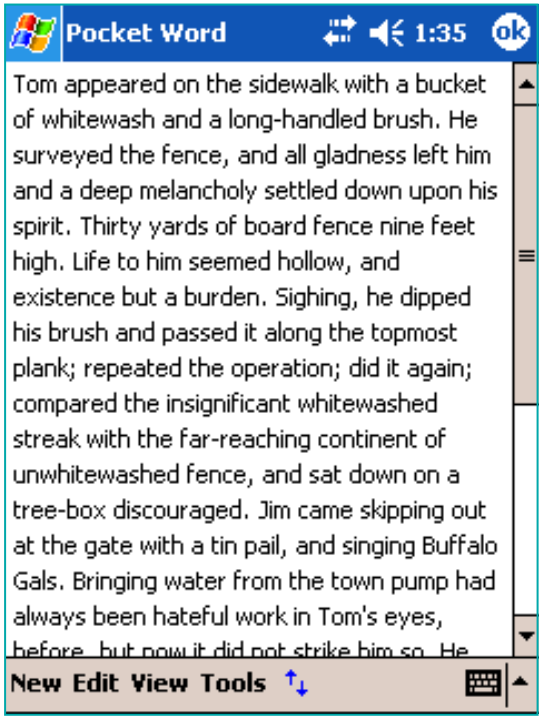
# The Wedge

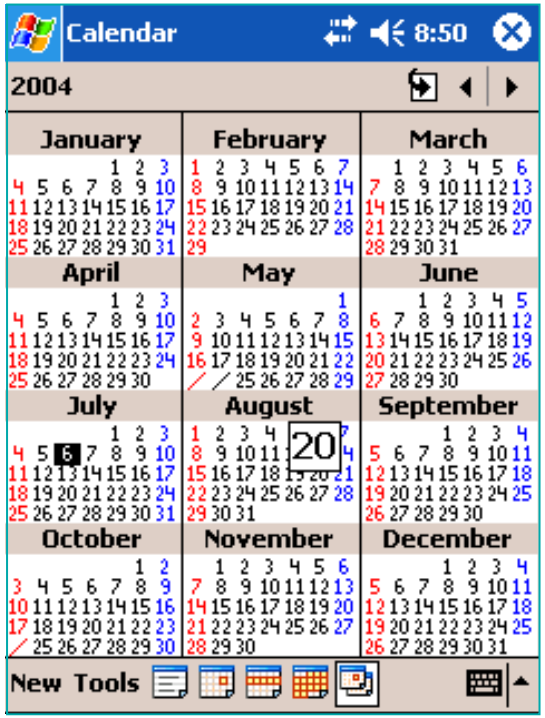
- Degrees of freedom
  - Rotation
  - Intrusion
  - Aperture

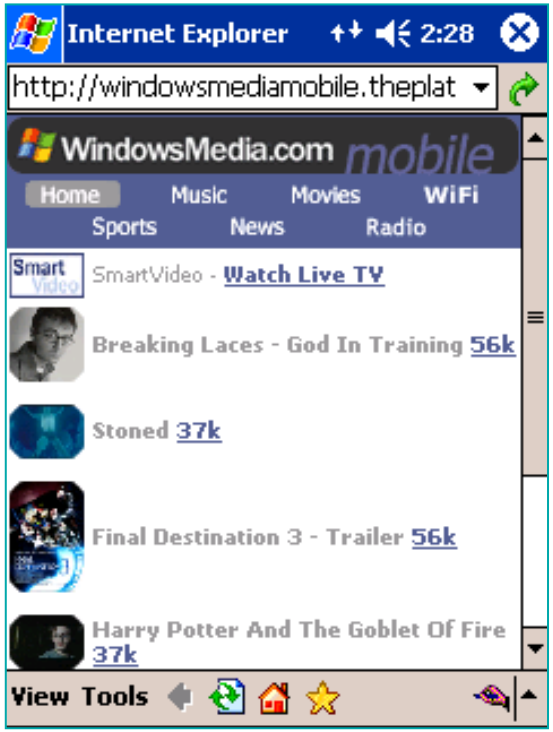


# Improving Touch Screen Accuracy

# Small Displays → Small Targets



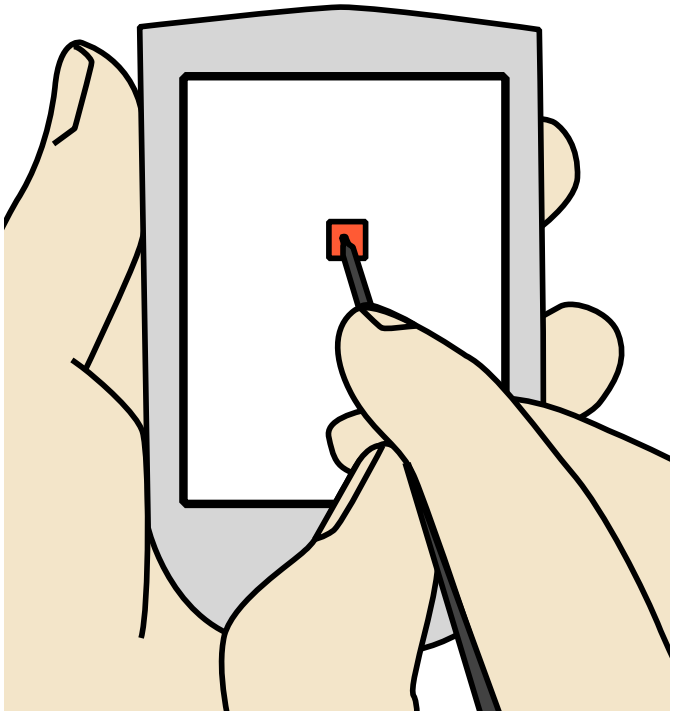



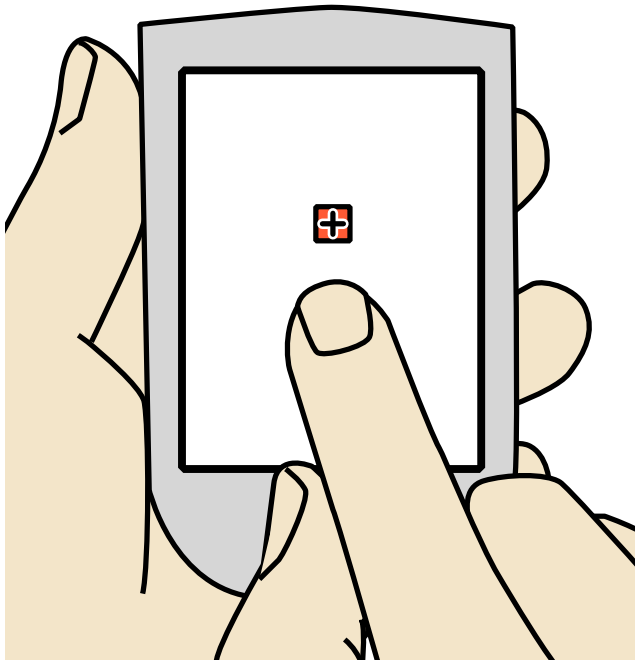

Source: Patrick Baudisch

# Stylus vs. Direct Finger Input

- Stylus or pen
  - Grabbing stylus takes to long for short interactions
- Bare finger input
  - Unclear contact point, imprecise
  - Finger occludes target



# Offset Cursor (Potter et al., 1988)



Potter, Weldon, Shneiderman: Improving the accuracy of touch screens: an experimental evaluation of three strategies. CHI 1988.

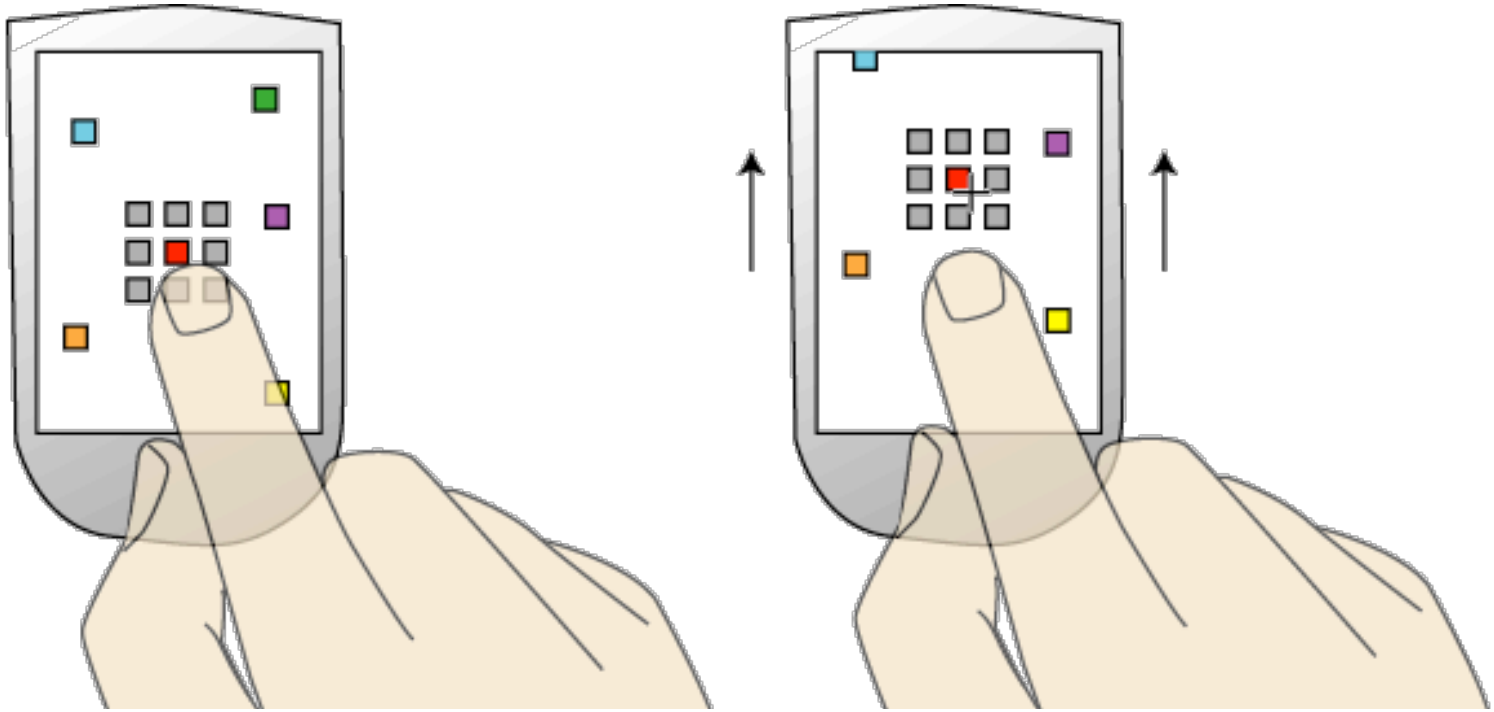
Disadvantages of this “software stylus”

1. No visual feedback until contact, need to estimate offset
2. Makes some display areas unreachable
3. Unexpected offset affects walk-up-and-use scenarios

Source: Patrick Baudisch

# Shifting the Whole Screen

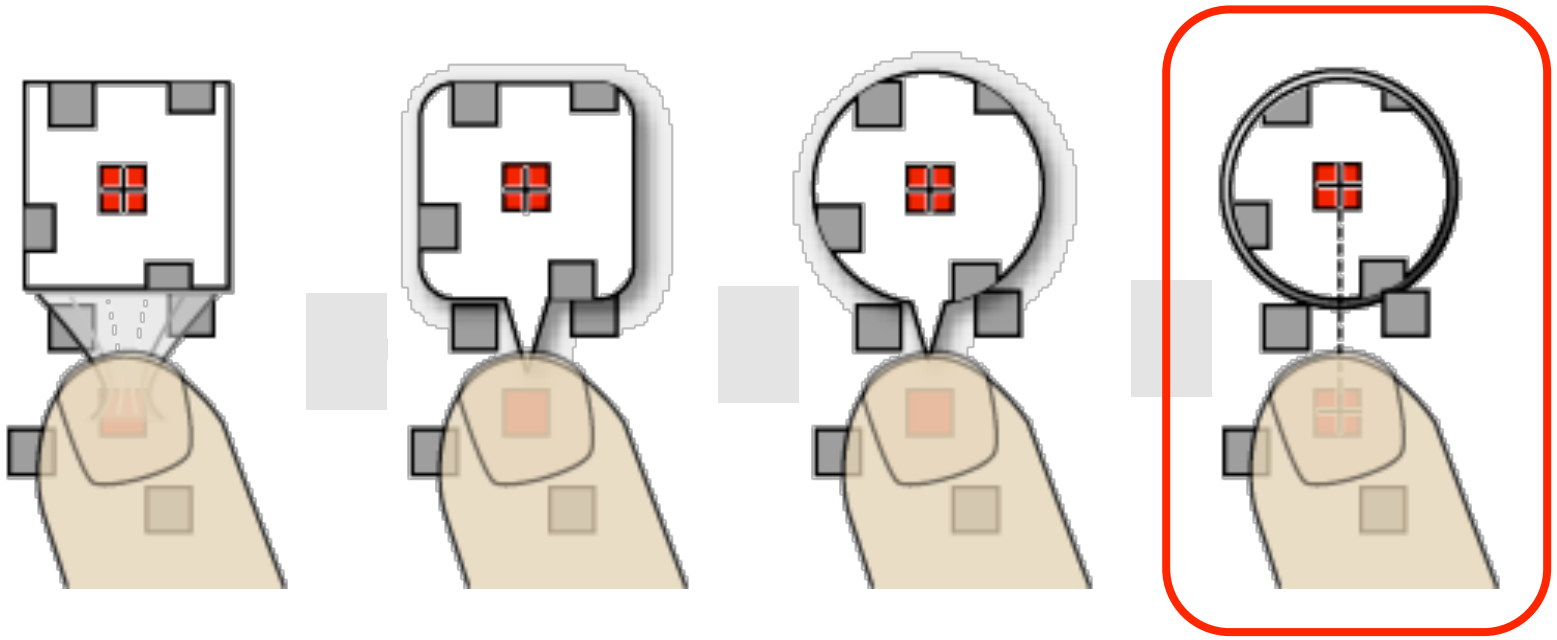
- Shifting the whole screen is distracting
- Disorients users, negatively impacts performance



Source: Patrick Baudisch

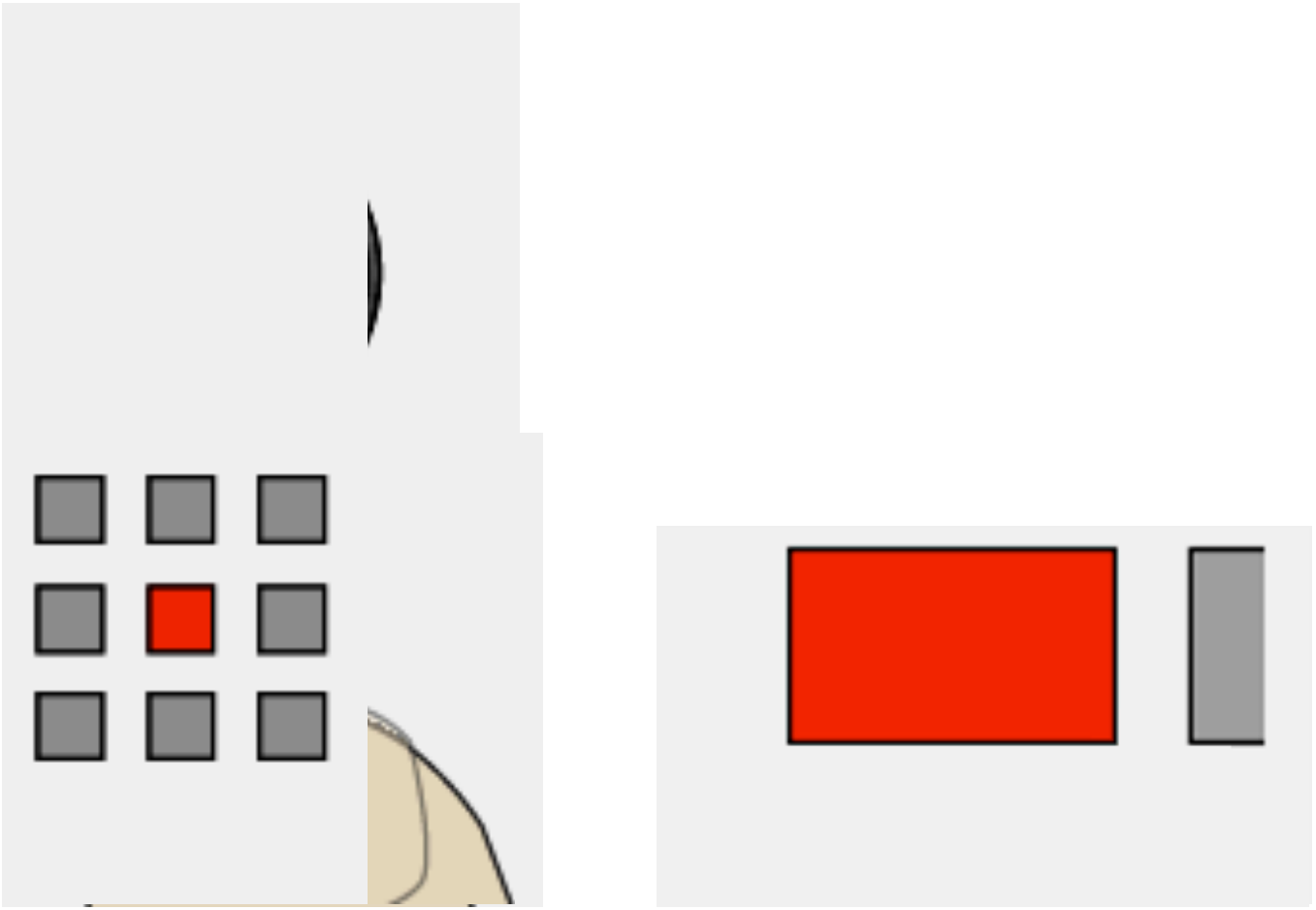
# Shift Callout (Vogel & Baudisch, 2007)

- Only shift callout
- Enough context around target
- 26mm circular shape → occluded area under finger



Source: Patrick Baudisch

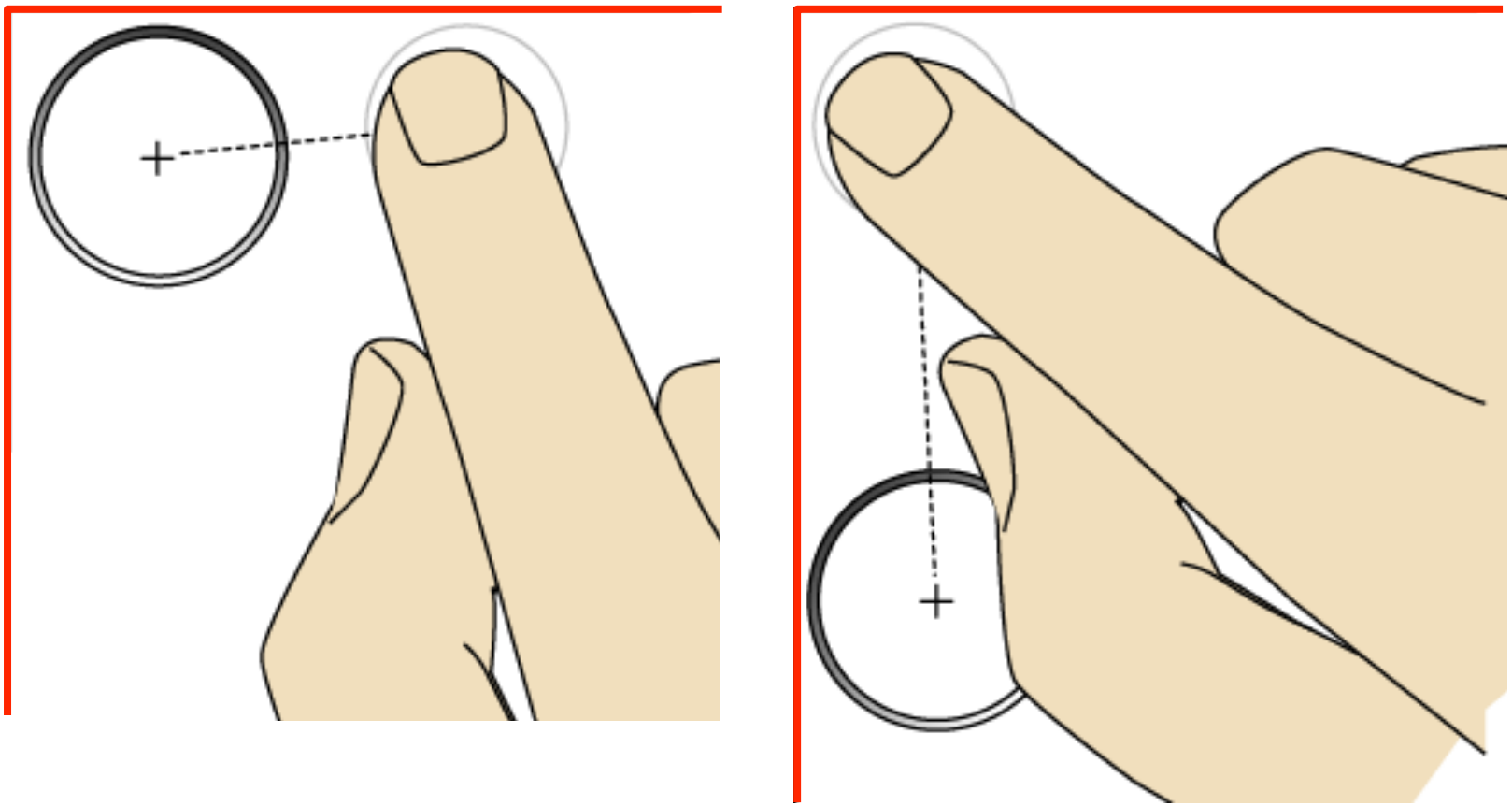
# Shift Needed Only for Small Targets



no offset, click on the target itself

Source: Patrick Baudisch

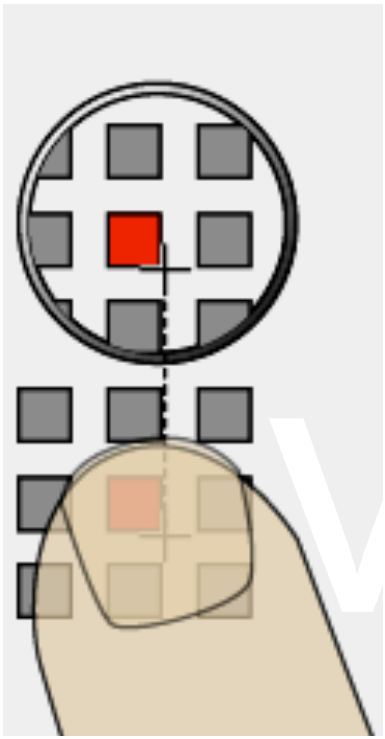
# Corners and Edges

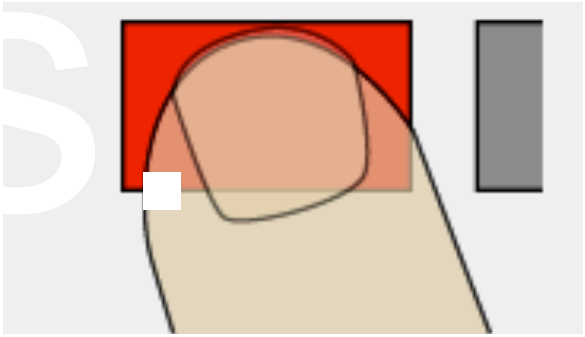


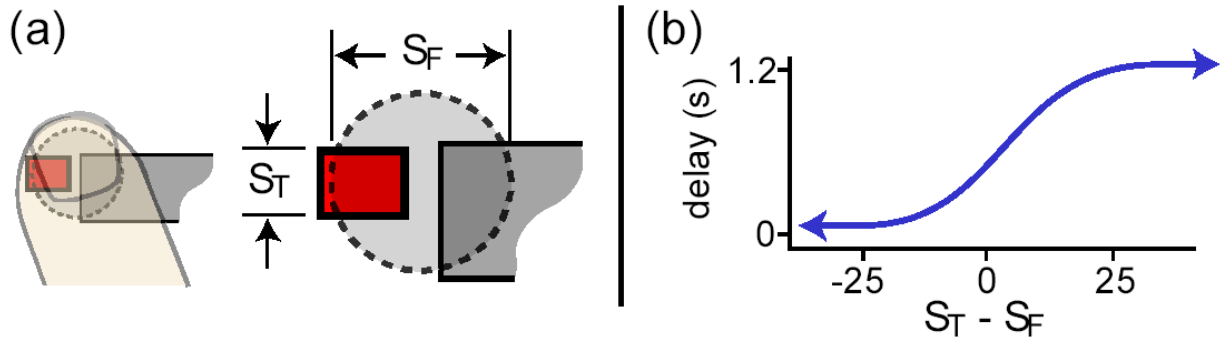
callout can go anywhere, no edge problems

Source: Patrick Baudisch

# When to Show the Callout








$S_T$ = target size

$S_F$ = finger occlusion size

by default: dwell time (300 ms)

extension: larger target → longer dwell time

extension: shift learns dwell times

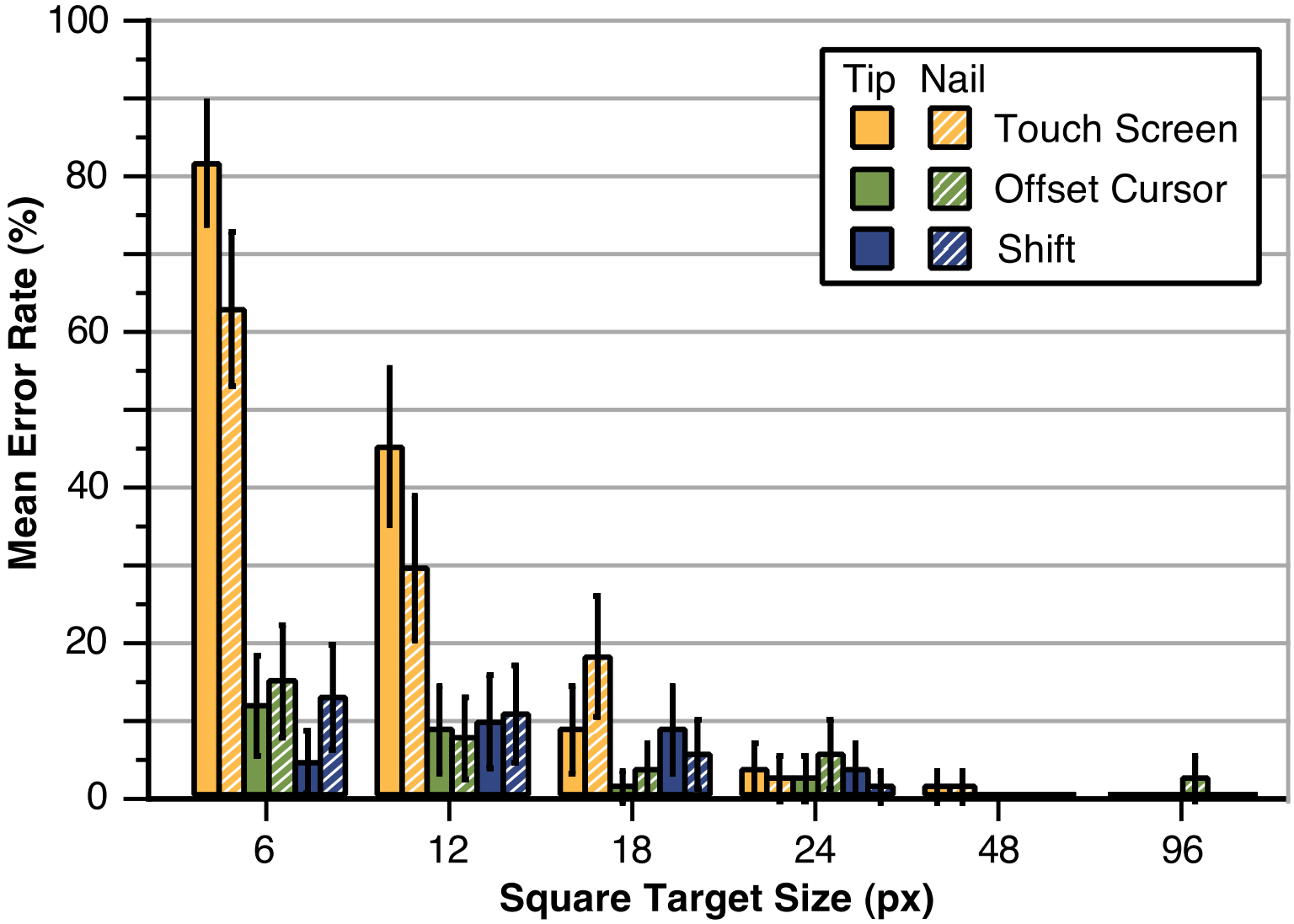
Source: Patrick Baudisch

# Experiment: Shift vs. Offset vs. Touch

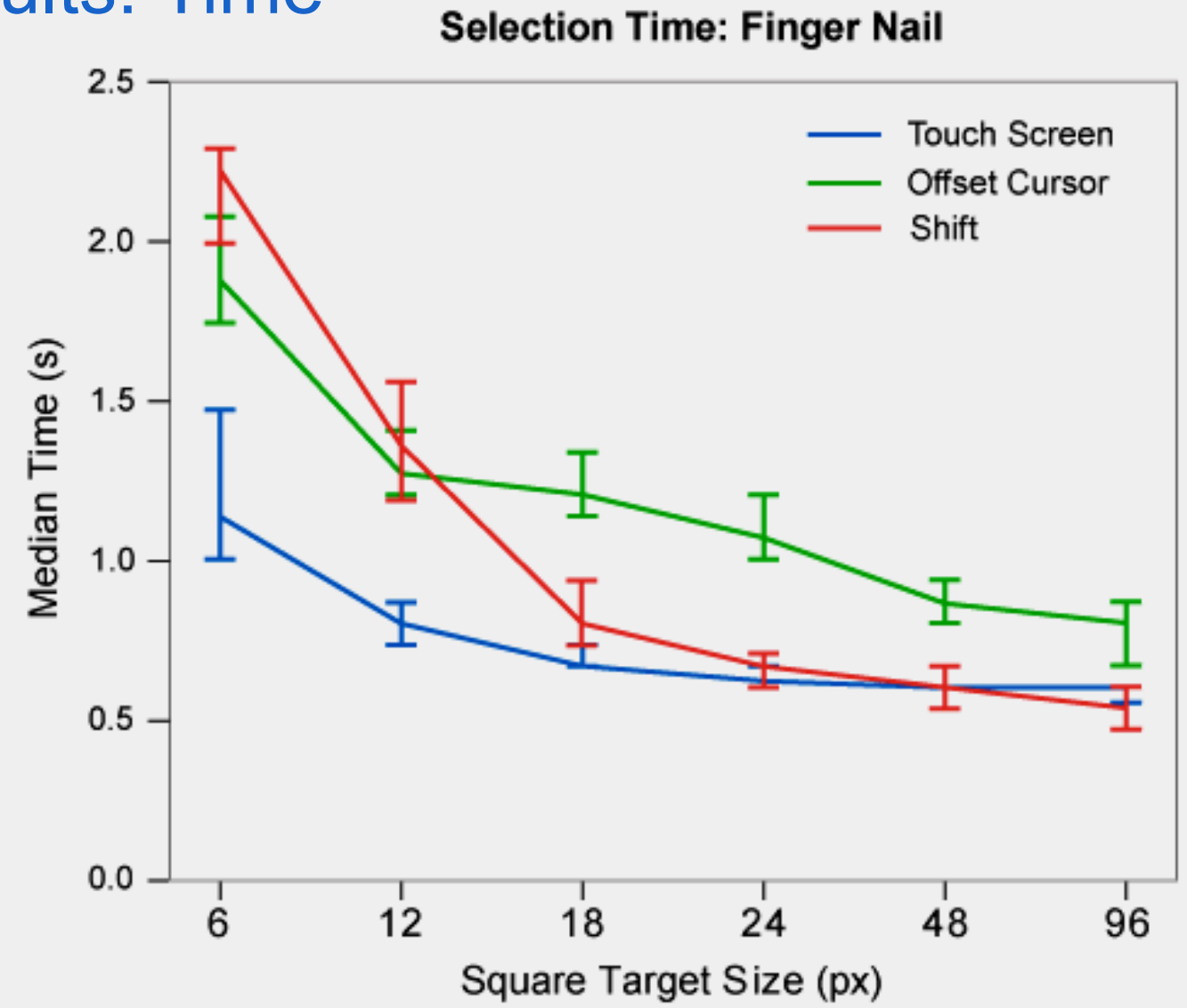
- Independent variables
  - 3 techniques: shift, offset, touch
  - 2 finger styles: nail, tip
  - 6 target sizes

Source: Patrick Baudisch

# Results: Error Rate

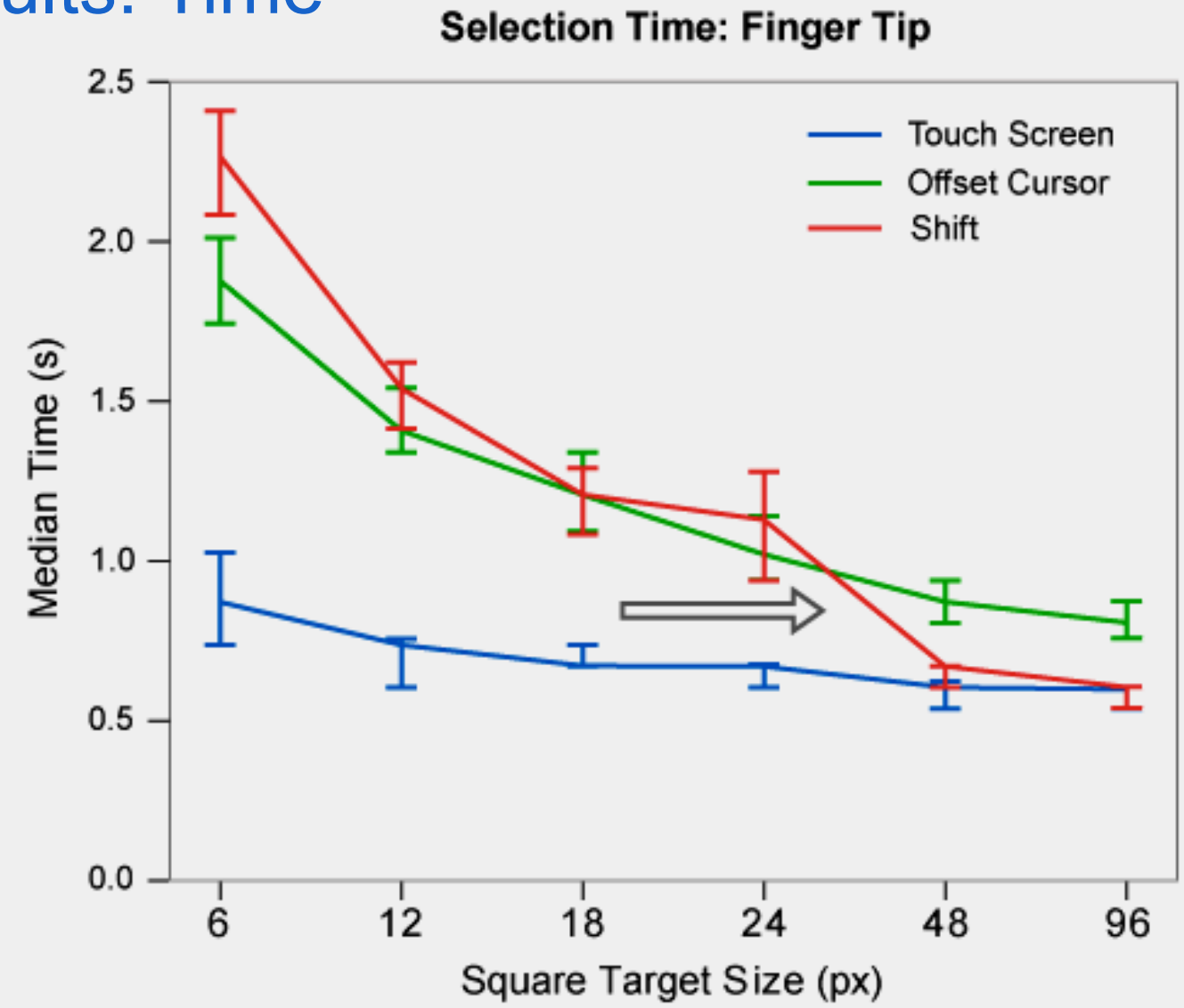


# Results: Time




Source: Patrick Baudisch

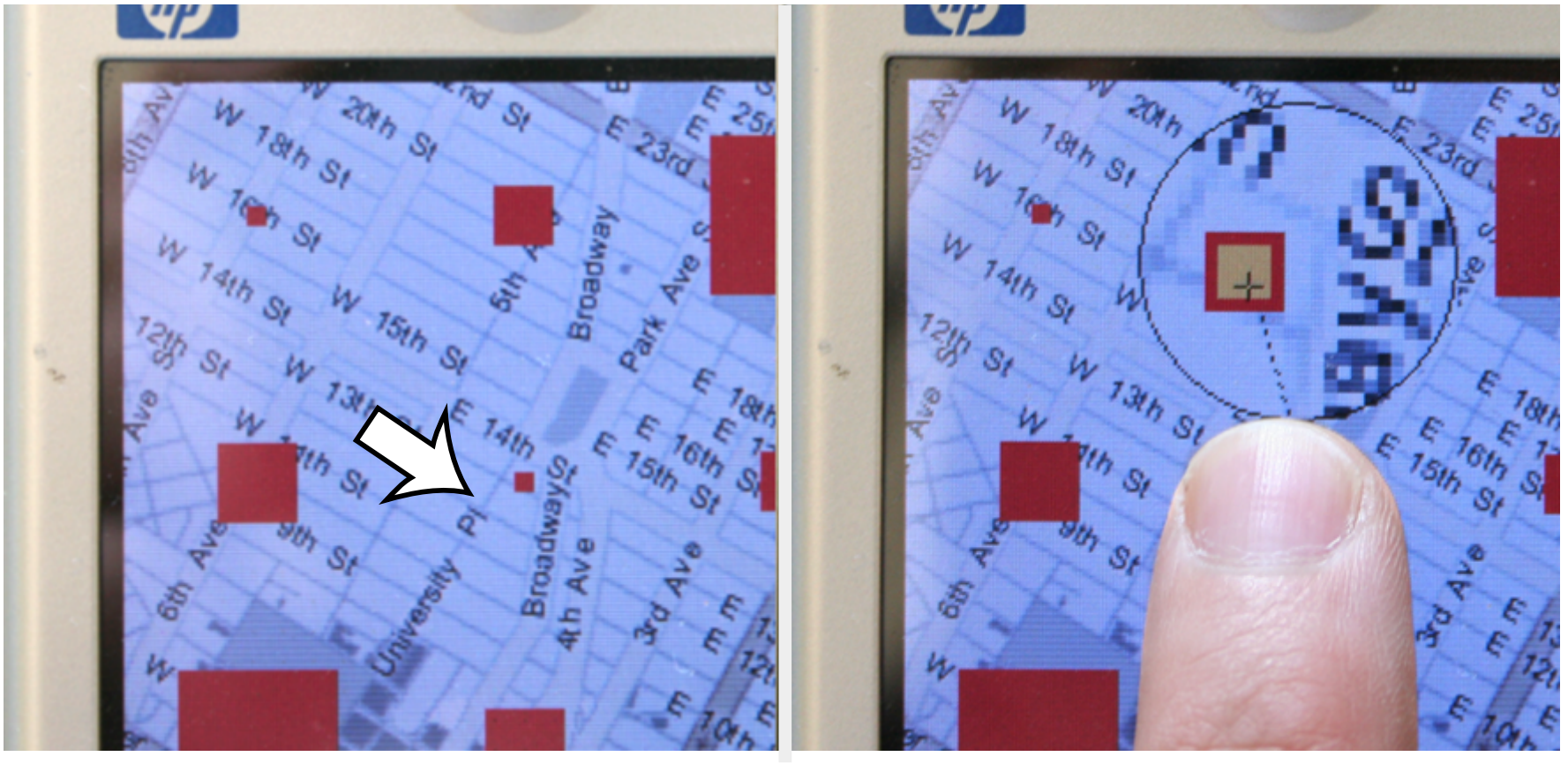
# Results: Time




Source: Patrick Baudisch

# Shift + Zoom

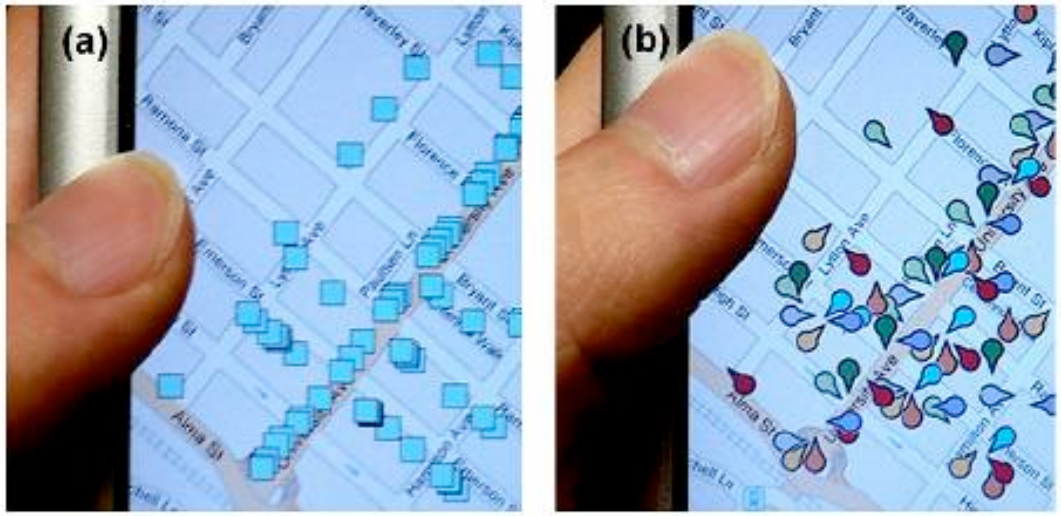
- Increased callout diameter to compensate for less context




Source: Patrick Baudisch

# Escape: A Target Selection Technique Using Visually-cued Gestures

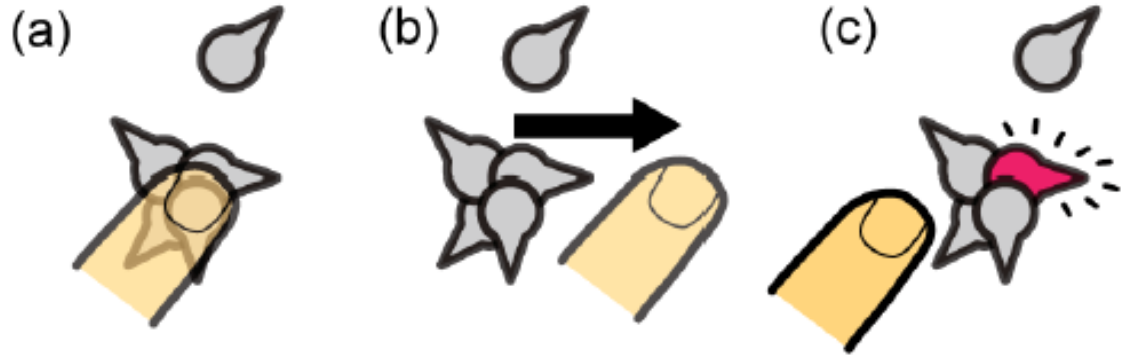
- Problem: Selecting a target that is surrounded by other selectable objects
- Solution: Icons in “Escape” indicate directions. A finger tap followed by a movement enables disambiguation.




Yatani, Partridge, Newman: Escape: A Target Selection Technique Using Visually-cued Gestures, CHI 2008

# Escape: A Target Selection Technique Using Visually-cued Gestures

- Icons in “Escape” indicate directions. A finger tap followed by a movement enables disambiguation.

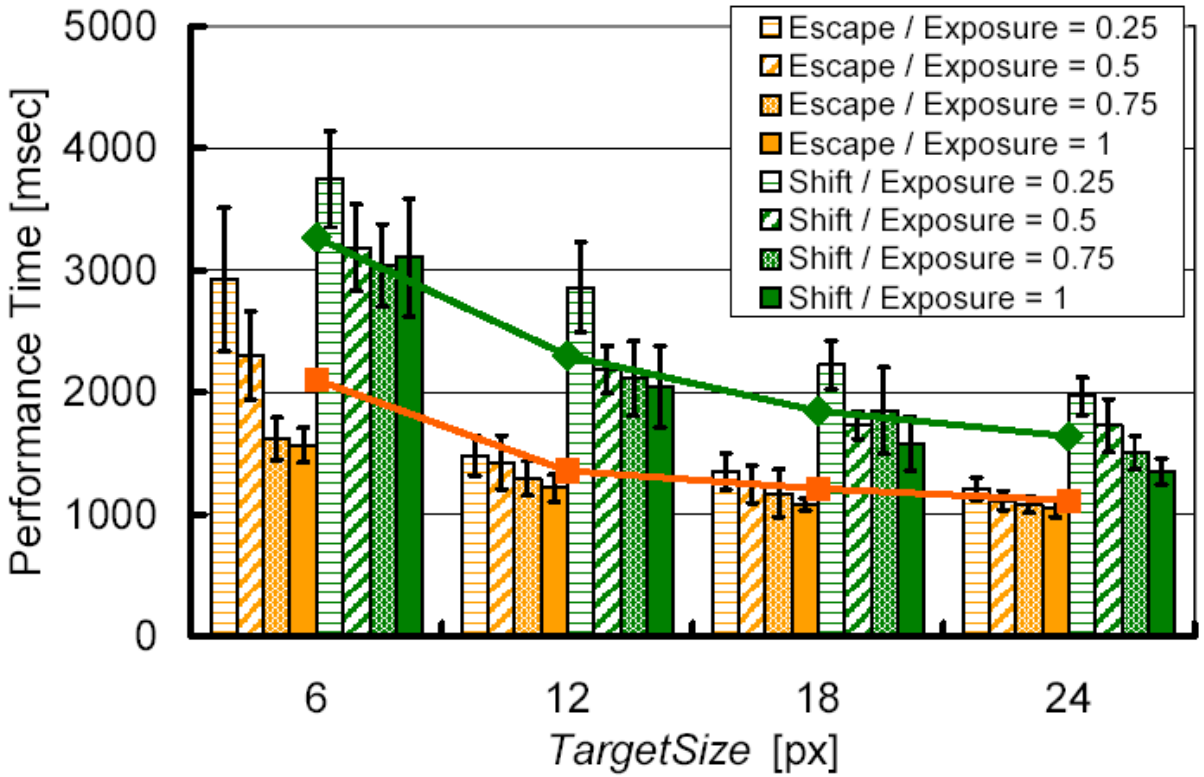



- Can handle 2.3 icons per square centimeter
- Find an assignment that separates gestures
  - Similar to graph coloring → NP-complete
  - “Escape” uses heuristic algorithm

http://www.youtube.com/watch?v=x3NeZswKkKw

# Experiment: Escape compared to Shift

- Independent variables
  - Technique: Escape or Shift
  - Target size: 6, 12, 18, 24 pixels
  - Exposure (fraction of target visible): 0.25, 0.5, 0.75, 1
- Results
  - Escape significantly faster than Shift
  - No significant difference in error rate



# The End