

Mobile UI

Multi-touch Devices

Input, Interaction Characteristics

Design Guidelines

Desktop and Mobile



Why touch?



Space optimization!

- Touch screens combine input and output, which optimizes the display/output area
- Allow interfaces to be customized

Jane Pyle [Follow](#)

I HATE that I have to use a touchscreen in my car to adjust volume. Takes attention off the road. Sometimes a knob is just perfect.

Desktop and Mobile

The image shows a side-by-side comparison of the Google Mail interface on a desktop browser and a mobile phone.

Desktop View (Left):

- Header:** Google, search bar, and search icon.
- Navigation:** Gmail dropdown, compose button, inbox count (7), and navigation icons.
- Inbox List:** Shows 7 emails from various senders like Google+, Merced Flores, Lisa Paik, etc., with subject lines like "Julia, a few Google+ posts you n..." and "Re: consultant for book - Hi Julia".
- Metrics:** 0.17 GB (1%) of 15 GB used, Manage link, Terms and Privacy links.
- Bottom:** Contact cards for Julia and Henri Rousseau, and standard browser navigation icons.

Mobile View (Right):

- Header:** Primary tab, search icon, and signal/battery/time indicators.
- Navigation:** Three-line menu icon.
- Inbox List:** Shows 7 emails categorized into Social (1 new), Promotions (2 new), and Updates (1 new). Examples include "Julia, a few Google+ posts you n...", "Zagat, Google Offers", and "Google Play".
- Bottom:** Standard mobile navigation icons (back, home, recent).

Device Characteristics

- Limited resources
 - Limited memory
 - Limited processing
 - Battery conservation
- Primarily touch interaction
 - Input capabilities and challenges
- Mobile form factor
 - Small display size
 - Different aspect ratios (orientations)
 - Single application focus



Design is about Constraints

“One way to look at design — at any kind of design — is that it’s essentially about constraints (things you have to do and things you can’t do) and tradeoffs (the less-than-ideal choices you make to live within the constraints).”

- Steve Krug (“Don’t Make Me Think Revisited”)

Consequences of this Design?

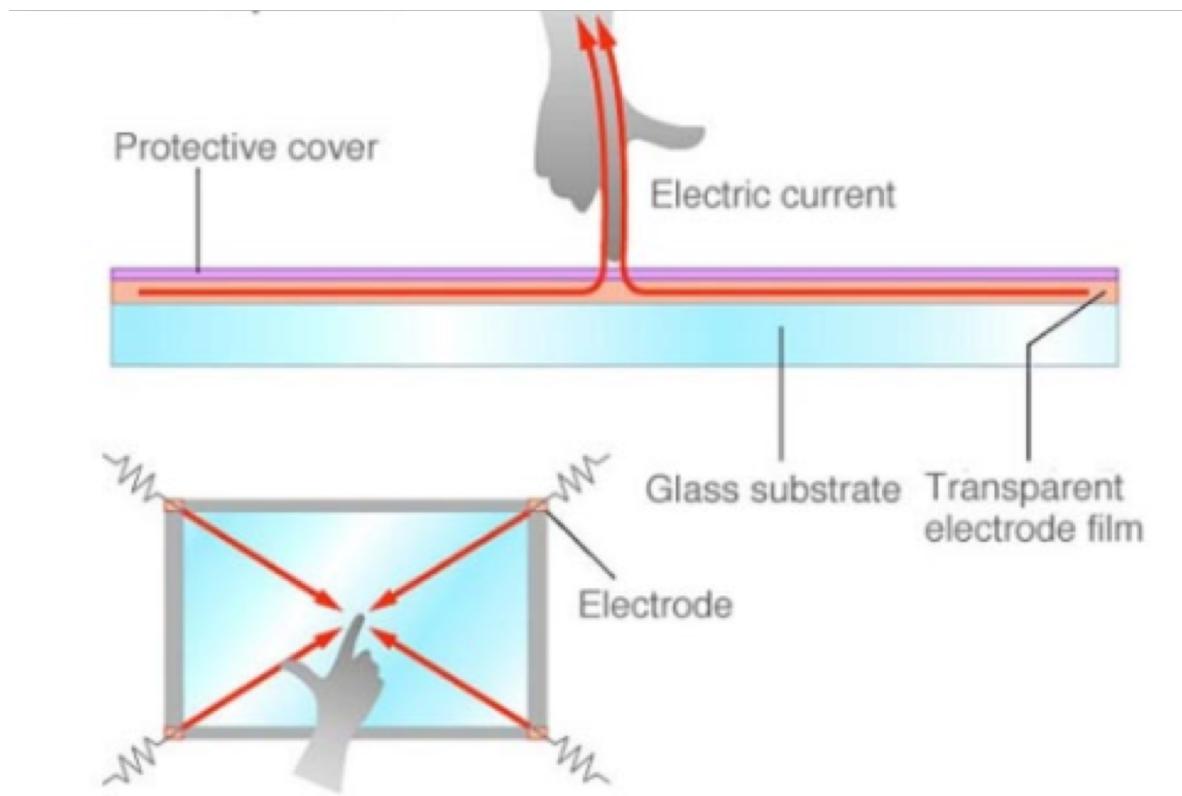
- Limited processing capabilities
 - Intensive tasks need to be done offline/preprocessed
- Single application model
 - One app in the foreground, others suspended
 - Few active background processes
- Primarily full-screen apps, consisting of a sequence of screens
 - Limits interaction but also limits processing requirements
- Responsiveness
 - connectivity, data rates, reliance on server

→ Big implications for UI programming model

It's all about the screen.

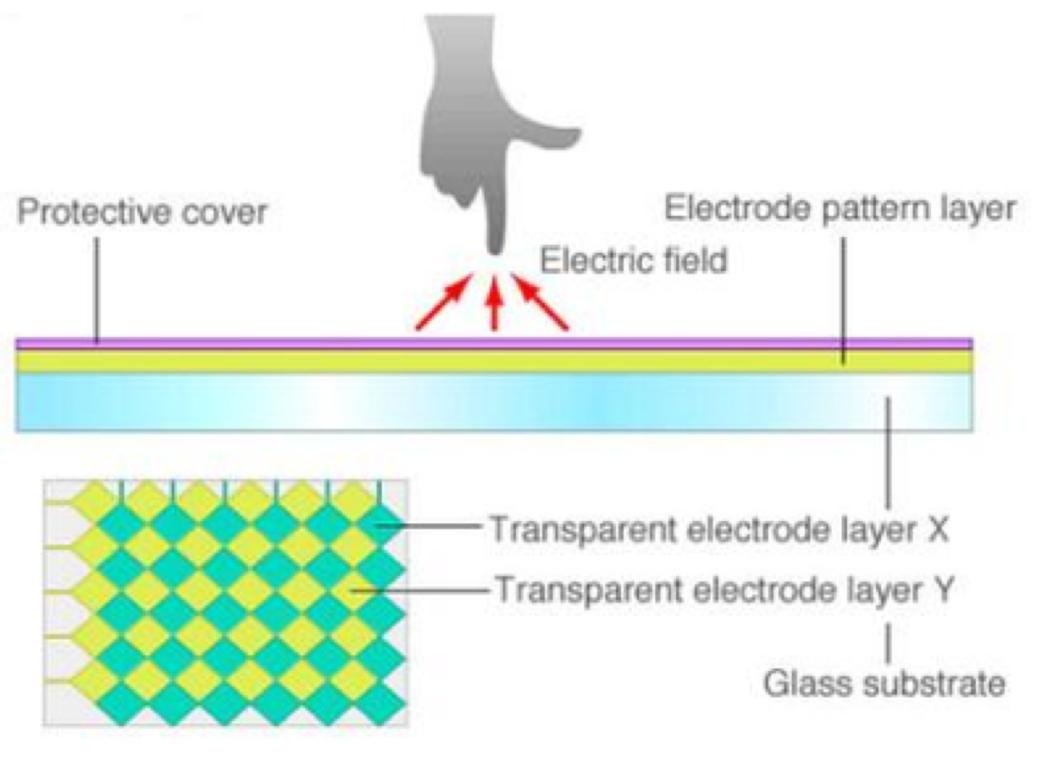
Capacitive Touch Screen Technology

- Finger changes material capacitance
- **Surface Capacitance**
 - voltage applied to conductive material creates *electrostatic field*
 - a finger touch creates a capacitor
 - measure effective capacitance at four corners to localize touch



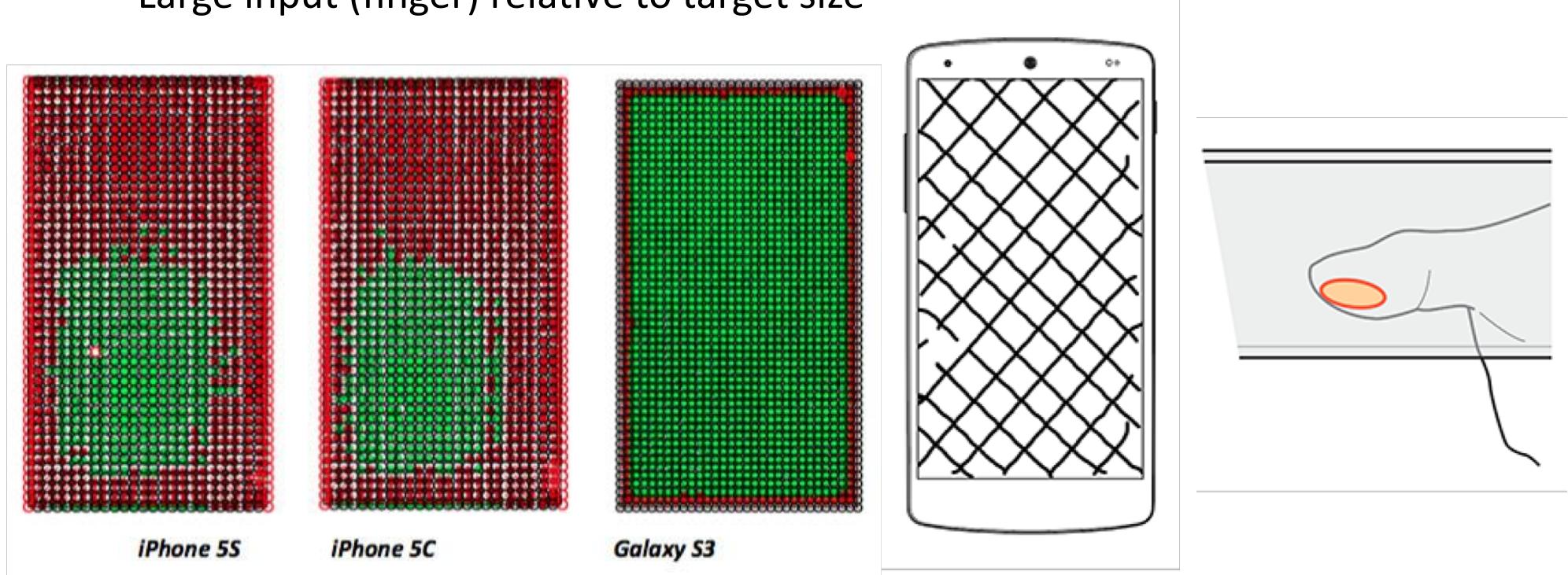
Capacitive Touch Screens

- Finger changes material capacitance
- **Projective Capacitive (PCT, PCAP)**
 - X-Y grid of thin wires or electrodes (driving lines, sensing lines)
 - a capacitor at each wire intersection
 - measure effective capacitance each point



Touch Sensing Accuracy

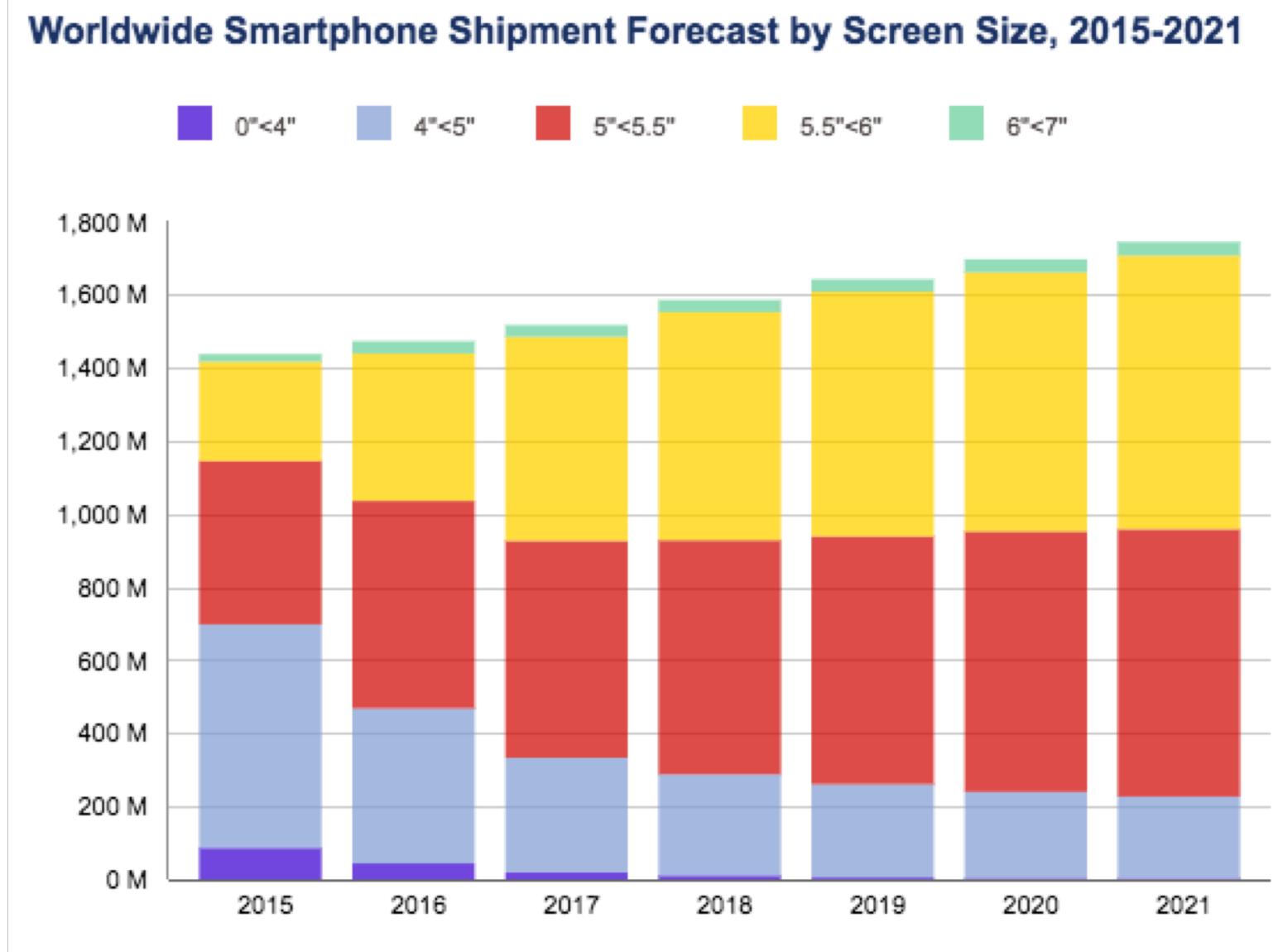
- Touch screen input is noisy
 - Sensors vary in their accuracy
 - Estimates for “pressure” very noisy
 - Large input (finger) relative to target size



Mobile UI

Design for Fingers, Touch and People, Steven Hoover (<https://www.uxmatters.com>)

Display Size





Windows Touch Digitizer Jitter Test Single Moving - Vertical

Automated Touch Screen Testing with Robots

- <https://youtu.be/qw3OkC5CaZU?t=49s>

Input & Interaction

Stylus versus Finger



Stylus



Finger

by Cindy Packard

Stylus versus Touch

PROPERTY	PEN	TOUCH
Contacts	1 point A single well-defined point.	1-10+ contact regions Often with shape information (Cao et al. 2008).
Occlusion	Small (pen tip) But hand still occludes screen.	Moderate ("fat finger") to Large (pinch, palm, whole hand gestures)
Precision	High Tripod grip / lever arm affords precision, writing & sketching tasks.	Moderate Nominal target size for rapid acquisition via touch is about 10-18 mm ² (Vogel and Baudisch 2007) (Sears 1993) (Lewis, Potosnak, and Magyar 1997)
Hand	Preferred hand	Either hand / Both hands
Elementary Inputs	Tap, Drag, Draw Path	Tap, Hold, Drag Finger, Pinch
Intermediary	Mechanical Intermediary Takes time to unsheathe the pen. Pen can be forgotten.	None : Bare-Handed Input Nothing to unsheathe, nothing to lose. No lever arm.
Acquisition Time	High (first use: unsheathe the pen) Moderate on subsequent uses: pen tucked between fingers.	Low No mechanical intermediary to acquire.
Buttons	Barrel Button, Eraser (some pens)	None
Activation Force	Non-Zero Tip switch or minimum pressure.	Zero (capacitive touch). Note that resistive touch requires some force.
False Inputs	Palm Rejection: Palm triggers accidental inputs, fingers drag on screen while writing, etc. This is a difficult problem. Designs must accommodate incidental palm contact when it inevitably occurs.	"Midas Touch Problem" Fingers brush screen, finger accidentally rests on screen while holding device, etc. "Chess Player's Syndrome" Device senses touch when none occurred. Common problem on optical touch-screens.

Multi-touch Input Characteristics

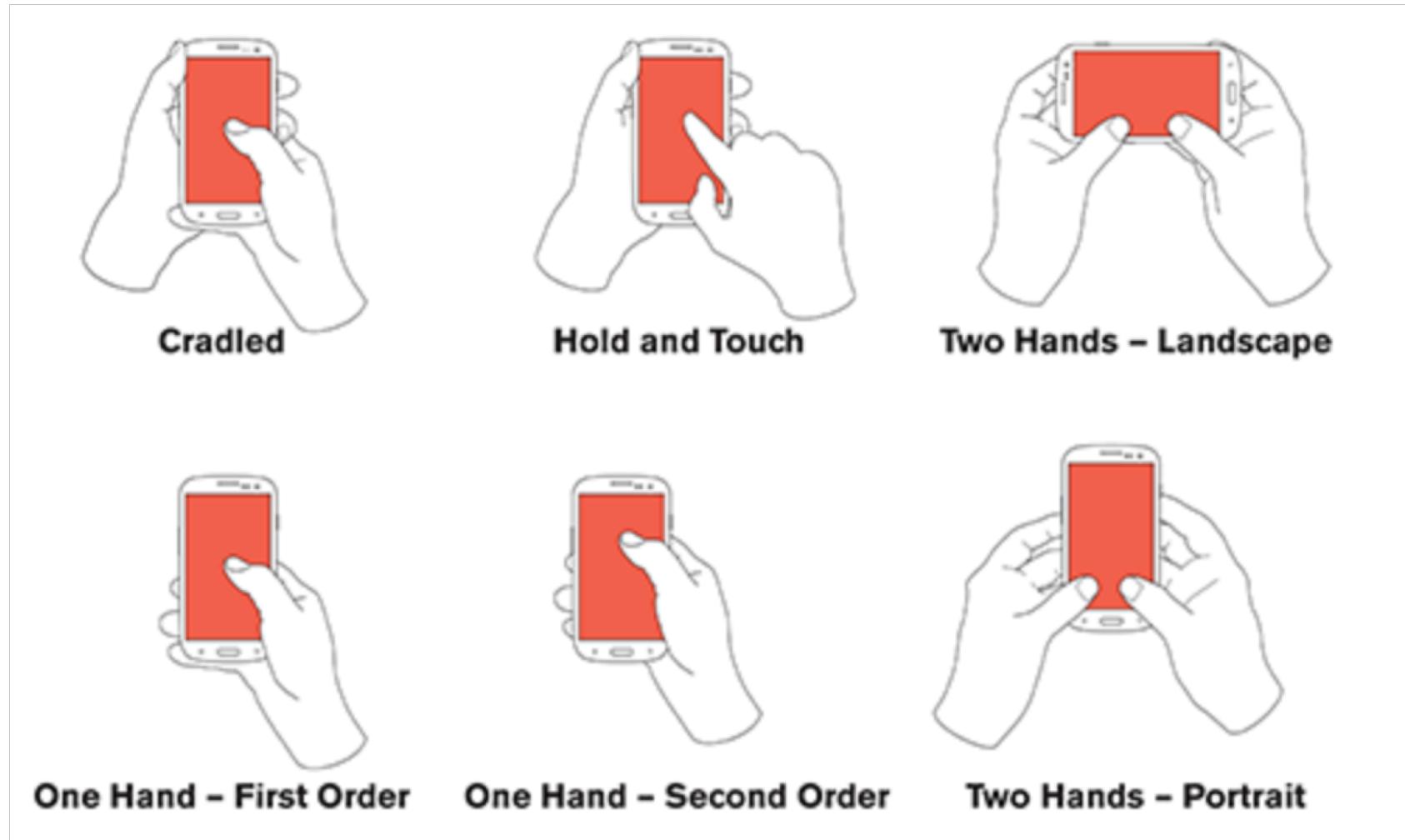
Devices can detect

- Number of points of contact (10+), and surface movement
- Finger pressure (Apple 3D touch)
- Device location and orientation (gyroscope, accelerometer, magnetometer)

Not widely available (yet)

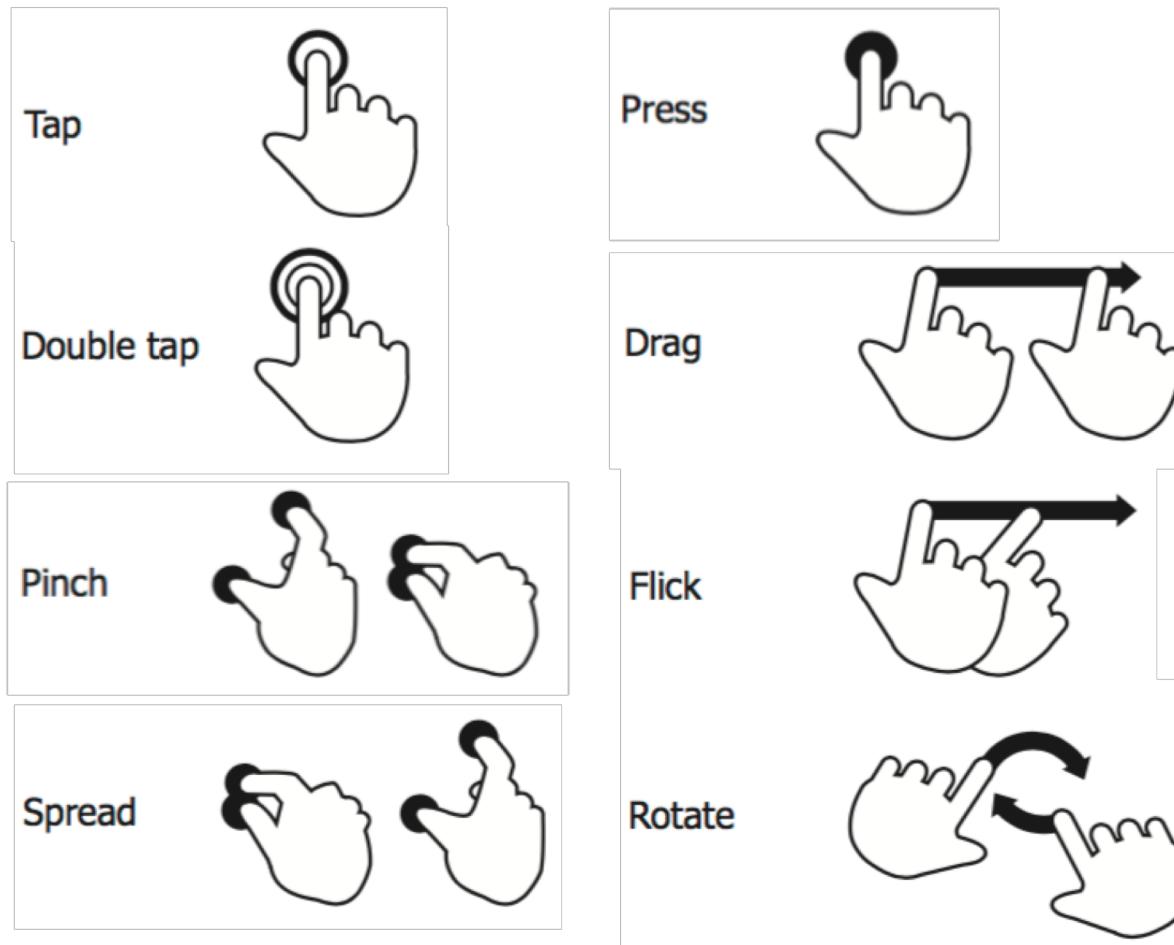
- Finger tracking (i.e. knowing which finger is being used)
- User orientation (e.g. sitting, standing)
- Context (e.g. running, walking)

Different Ways to Hold



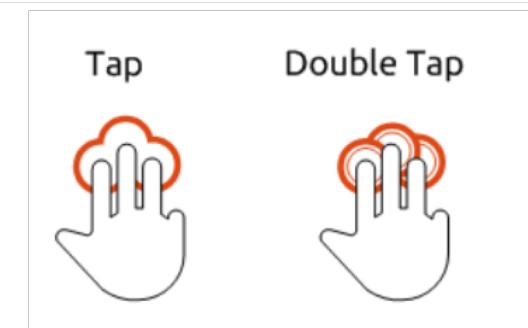
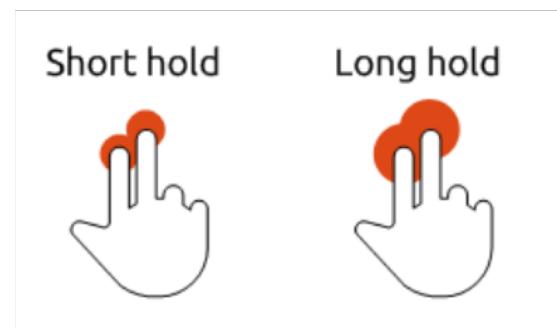
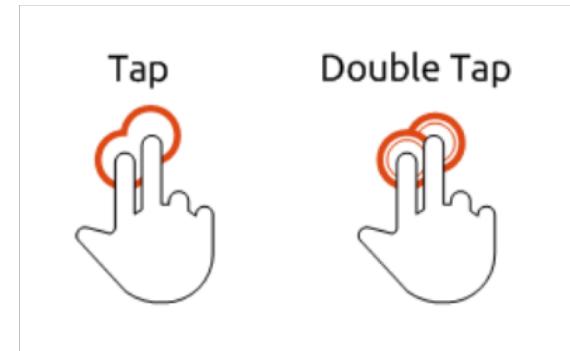
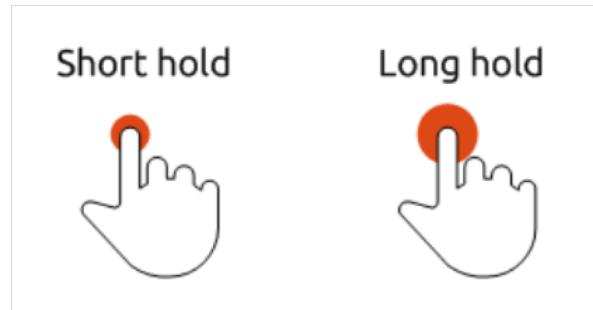
Standard Gestures

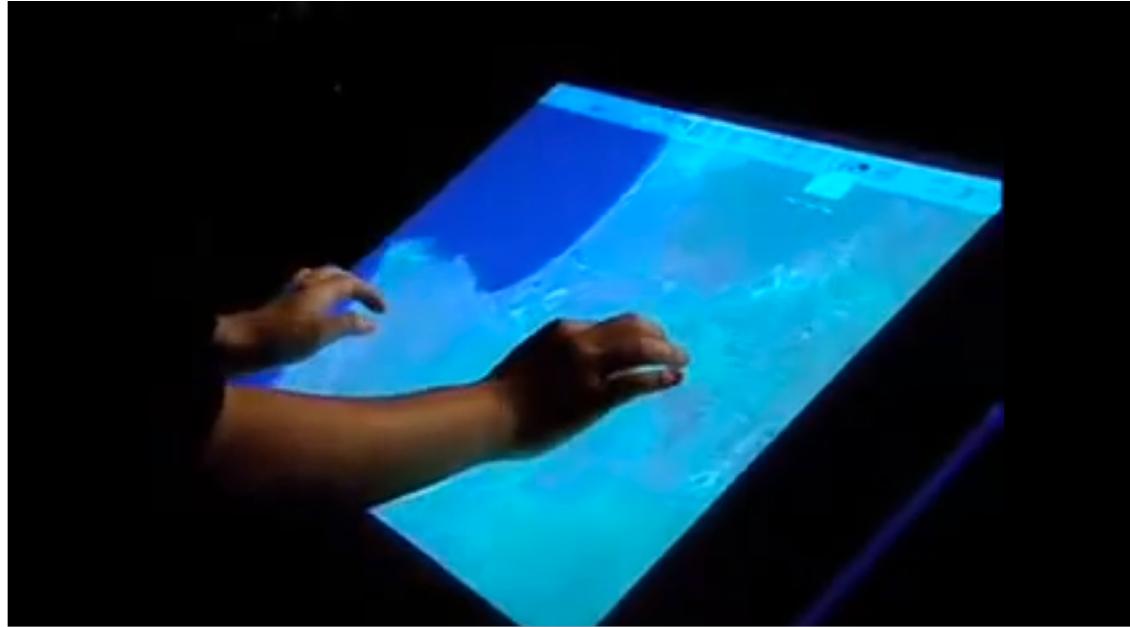
- Touch–screen interaction commonly uses simple, one or two-finger touches and swipes (i.e. we track position and motion on-screen).
- May be augmented with on-screen widgets.



Expanded Gestures

- We can increase expressivity with time-based or contact-based gestures; these aren't standard across applications, but do exist.
- Could also be augmented with voice, finger pressure, in-air gestures, but little commercial support (yet).
- Research suggests that gestures aren't "intuitive" or discoverable.





Jeff Han's "Lava Lamp" demonstration

<https://www.youtube.com/watch?v=QKh1Rv0PIOQ&noredirect=1>

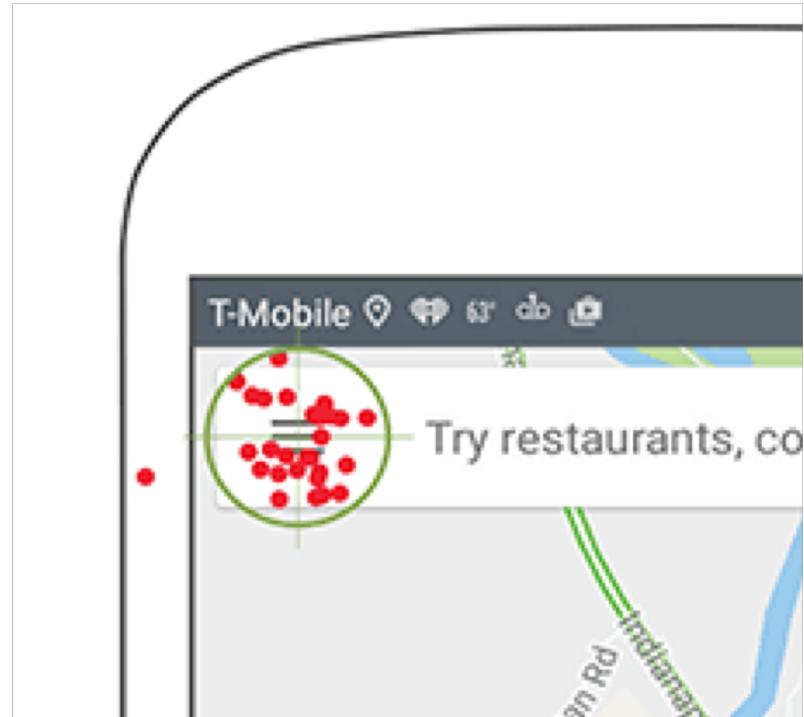
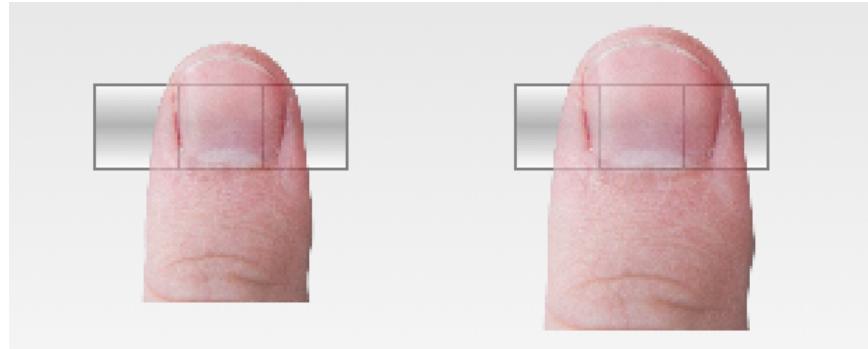
Direct Manipulation via Gestures



patentlyapple.com

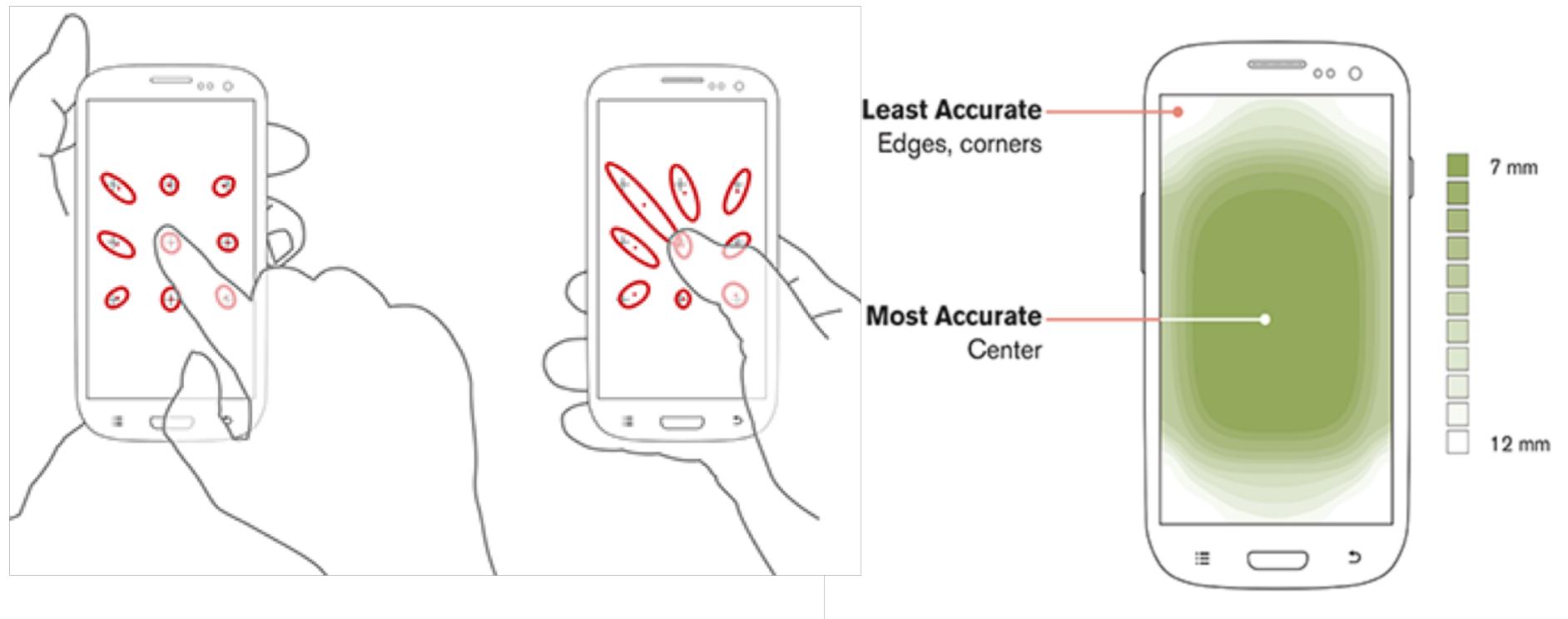
Challenge: Human Accuracy

- People have “fat fingers”, which leads to occlusion and precision issues
- Touch targets need to be large
 - Apple/iOS recommends 15mm
 - Google/Android recommends 9mm (min 7mm; min spacing 2mm)



Challenge: Human Accuracy Varies By Position and Grip

- Accuracy affected by
 - Hand posture (i.e. hand is holding, and hand used to interact)
 - Finger vs. thumb used to interact
 - Walking vs. sitting

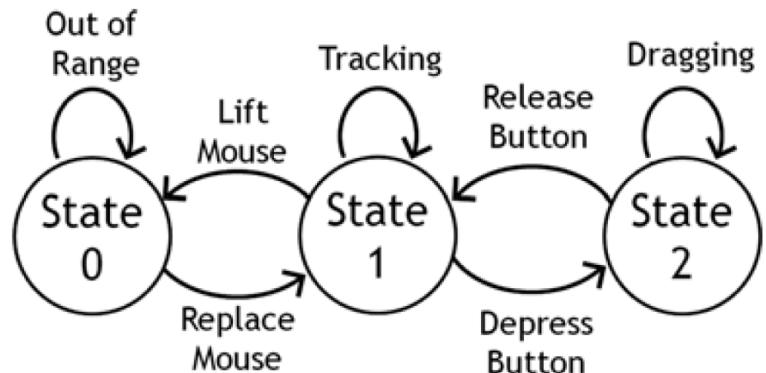


Challenge: No Hover State in Touch

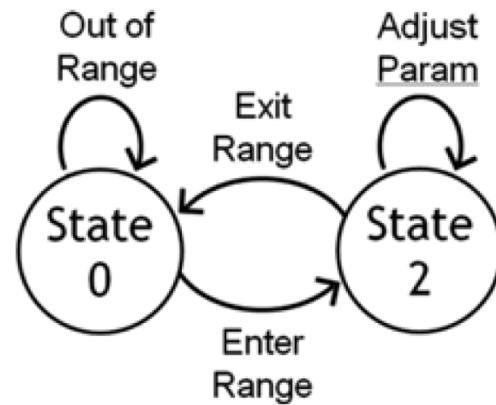
Having a middle “tracking” input state allows for hover (e.g. mouse). Users can preview an action before committing

- Mouse input typically supports 3-states (i.e. not touching, dragging, mouse-down)
- Touch input only supports 2-states (i.e. touching or not-touching the screen).

mouse input states



touch input states



“Imprecision, Inaccuracy, and Frustration: The Tale of Touch Input” by Benko and Wigdor

Challenge: Multi-touch Dispatch Ambiguity

- In multi-touch, multiple fingers may hit a control simultaneously
... leading to ambiguity
- When is click event generated? There are a number of possibilities:
 - “click” events generated for buttons only when the last contact is lifted from the control, or
 - “click” events generated every time a user taps a button, even if another finger is holding it down, or
 - over-capture: multi-touch controls captured by more than 1 contact simultaneously (e.g., selecting the thumb of a slider with two fingers can mean that it will not track directly under a single finger when moved.)

Challenge: Physical Constraints

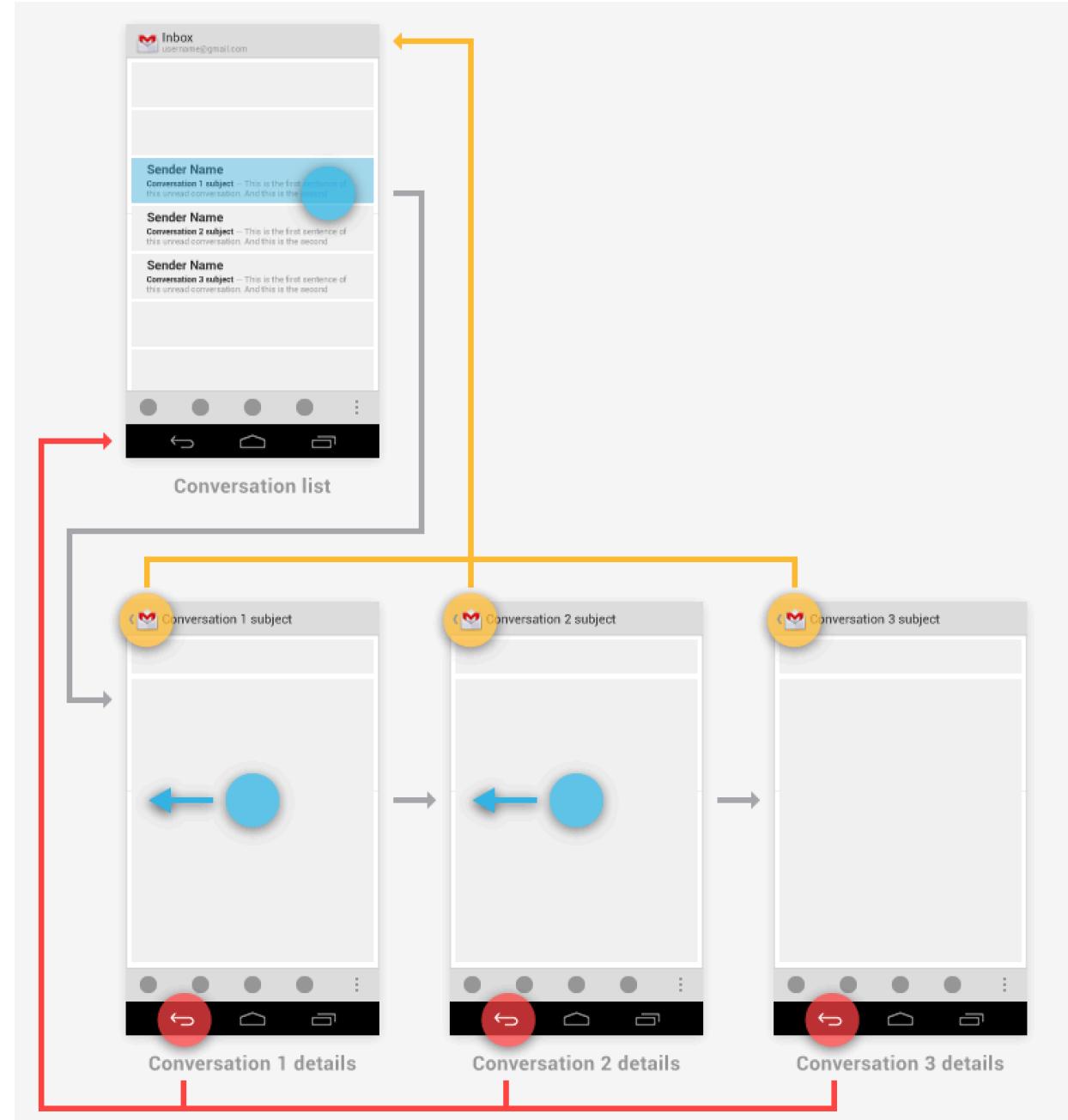
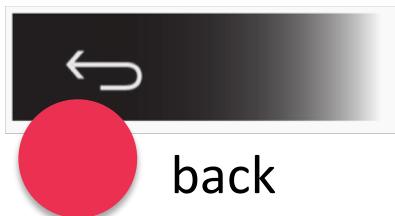
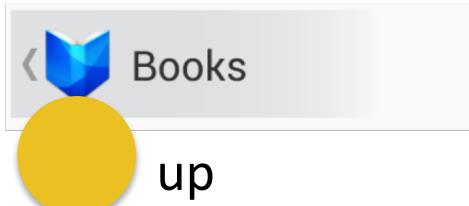
- Touch input relies on the principle of direct manipulation, i.e., user places their fingers onto an object, moves their fingers, and the object changes its position, orientation and size to maintain the contact points.
- Direct touch breaks when movement constraints are reached (e.g., moving beyond bounds, scrolling past limits).
 - This breaks immersion, and the sense of working with a physical object.
- Solution:
 - Elastic effects that mimic physical responses (e.g., Apple iPhone scrolling past a list, “snaps” back)

Design

Device Characteristics: Interaction

- **Assume one app at a time**
 - one app in the foreground
 - most apps are suspended when not in the foreground
- **Each app has window that fills the entire screen**
 - interaction is a sequence of different screens
 - consistent navigation model is key
- **Do not expect users to switch between applications**
 - Very difficult to lookup data in a different app
- **Controls need to be large to overcome occlusion and precision issues**
 - Also need to be selectable while moving (walking or running)

Navigation





Gesture Example: Clear

- <https://youtu.be/DFzjyf2E7KI?t=4s>

Standards: Interface Guidelines

- Platform-specific design guidelines can provide specific usage examples and hints, beyond these basic guidelines

The screenshot shows the Apple Developer Human Interface Guidelines page for iOS. It features three iPhone mockups displaying different screen layouts with blue UI elements and dashed grid lines. Below the phones, the text "iOS Design Themes" is visible, followed by a paragraph about the opportunity for app designers to deliver extraordinary products.

iOS Design Themes

As an app designer, you have the opportunity to deliver an extraordinary product that rises to the top of the App Store charts. To do so, you'll need to meet high expectations for quality and functionality.

iOS Design Guidelines

<https://developer.apple.com/design/human-interface-guidelines/>

The screenshot shows the Android Developers website under the DESIGN tab. The main heading is "Up and running with material design". Below it, there's a paragraph about the new design metaphor inspired by paper and ink. A sidebar on the left lists "Introducing material design", "Downloads for designers", and "Articles". At the bottom, there are two cards: "MATERIAL DESIGN Animation" (with a purple dots icon) and "MATERIAL DESIGN Style" (with a teal and yellow abstract shape icon).

Up and running with material design

Android uses a new design metaphor inspired by paper and ink that provides a reassuring sense of tactility. Visit the [material design](#) site for more resources.

> Introducing material design
> Downloads for designers
> Articles

MATERIAL DESIGN Animation

MATERIAL DESIGN Style

Android Design Guidelines

<https://developer.android.com/design/>

Android Design: Creative Vision

- (circa 2013, but still relevant today)

Enchant me

Beauty is more than skin deep. Android apps are sleek and aesthetically pleasing on multiple levels. Transitions are fast and clear; layout and typography are crisp and meaningful. App icons are works of art in their own right. Just like a well-made tool, your app should strive to combine beauty, simplicity and purpose to create a magical experience that is effortless and powerful.

Simplify my life

Android apps make life easier and are easy to understand. When people use your app for the first time, they should intuitively grasp the most important features. The design work doesn't stop at the first use, though. Android apps remove ongoing chores like file management and syncing. Simple tasks never require complex procedures, and complex tasks are tailored to the human hand and mind. People of all ages and cultures feel firmly in control, and are never overwhelmed by too many choices or irrelevant flash.

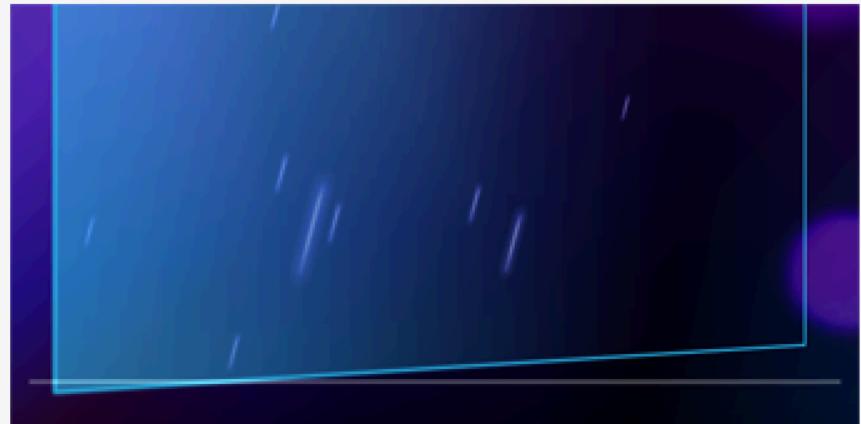
Make me amazing

It's not enough to make an app that is easy to use. Android apps empower people to try new things and to use apps in inventive new ways. Android lets people combine applications into new workflows through multitasking, notifications, and sharing across apps. At the same time, your app should feel personal, giving people access to superb technology with clarity and grace.

“Enchant Me”

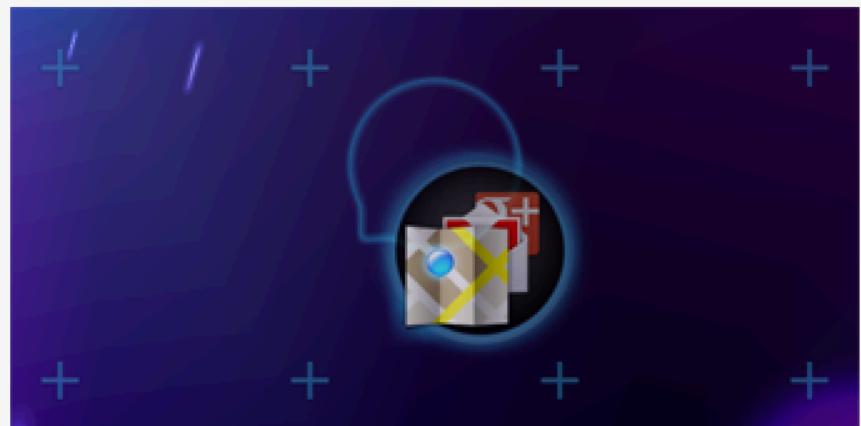
Delight me in surprising ways

A beautiful surface, a carefully-placed animation, or a well-timed sound effect is a joy to experience. Subtle effects contribute to a feeling of effortlessness and a sense that a powerful force is at hand.



Real objects are more fun than buttons and menus

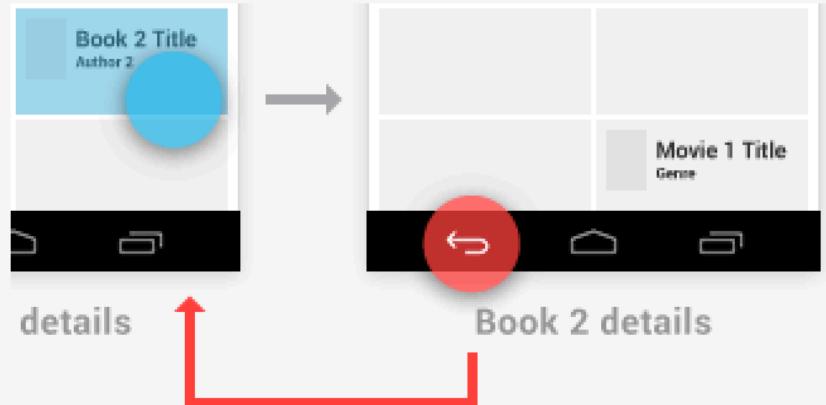
Allow people to directly touch and manipulate objects in your app. It reduces the cognitive effort needed to perform a task while making it more emotionally satisfying.



“Simplify My Life”

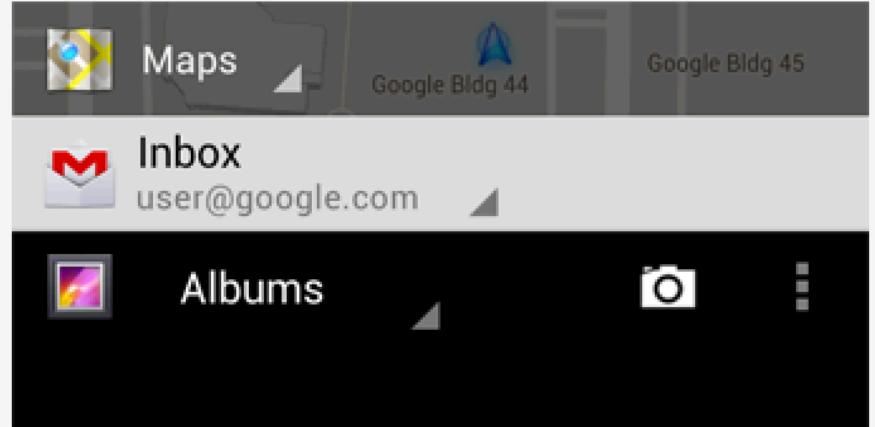
I should always know where I am

Give people confidence that they know their way around. Make places in your app look distinct and use transitions to show relationships among screens. Provide feedback on tasks in progress.



If it looks the same, it should act the same

Help people discern functional differences by making them visually distinct rather than subtle. Avoid modes, which are places that look similar but act differently on the same input.



“Make Me Amazing”

It's not my fault

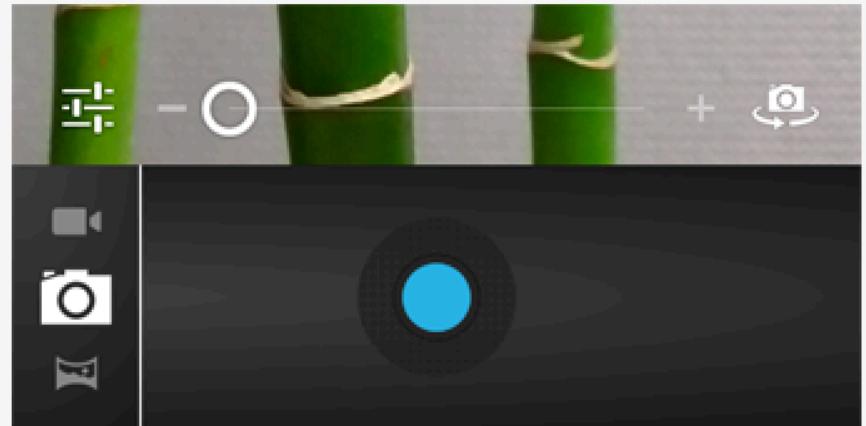
Be gentle in how you prompt people to make corrections. They want to feel smart when they use your app. If something goes wrong, give clear recovery instructions but spare them the technical details. If you can fix it behind the scenes, even better.

Insert SIM card

Turn off your phone, remove the battery, and carefully insert your SIM card with the gold contact side down. The cut-off corner should end up furthest away from the battery.

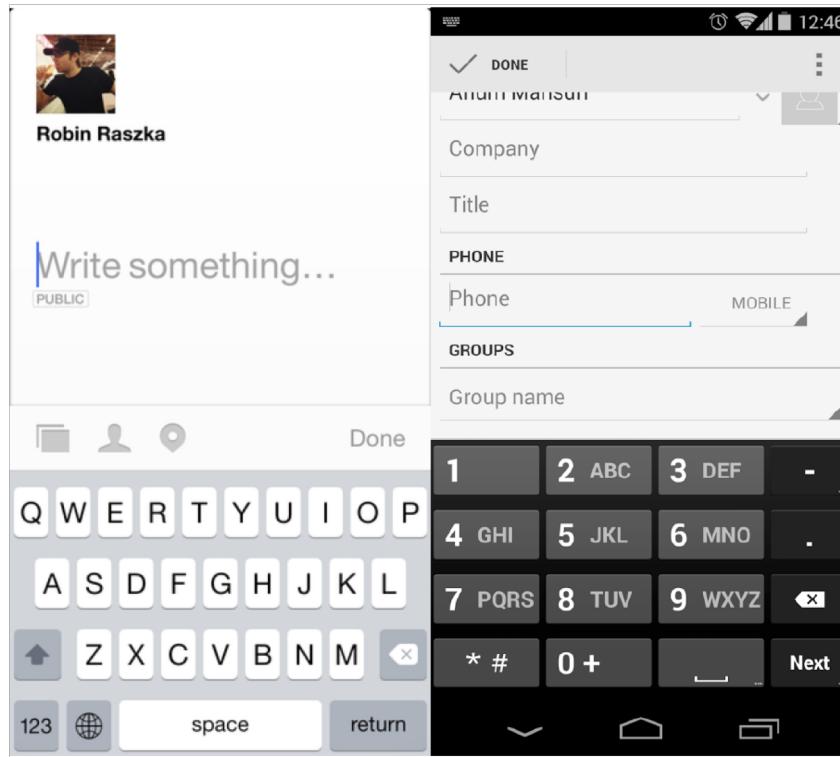
Make important things fast

Not all actions are equal. Decide what's most important in your app and make it easy to find and fast to use, like the shutter button in a camera, or the pause button in a music player.

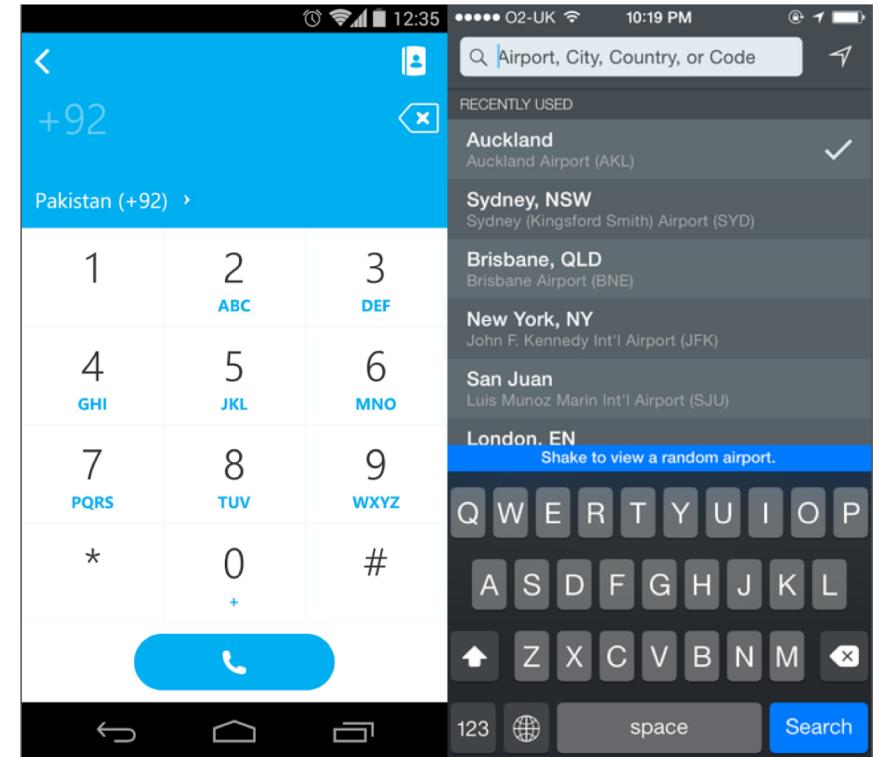


Help Users to Enter Information

Provide the Right Data Entry Tool



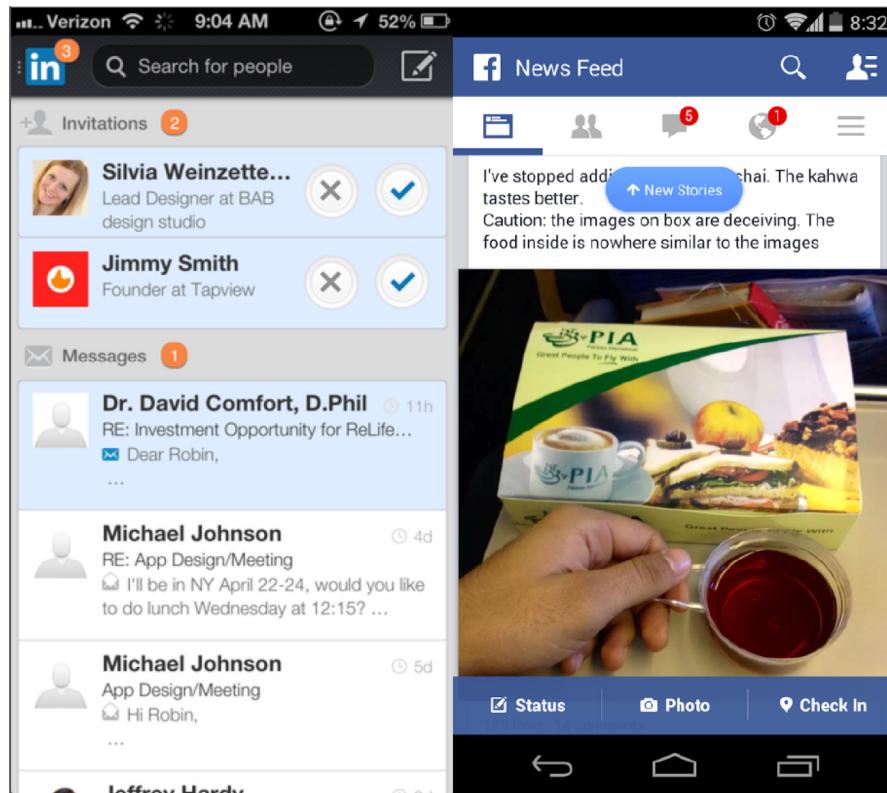
Anticipate and Predict Input



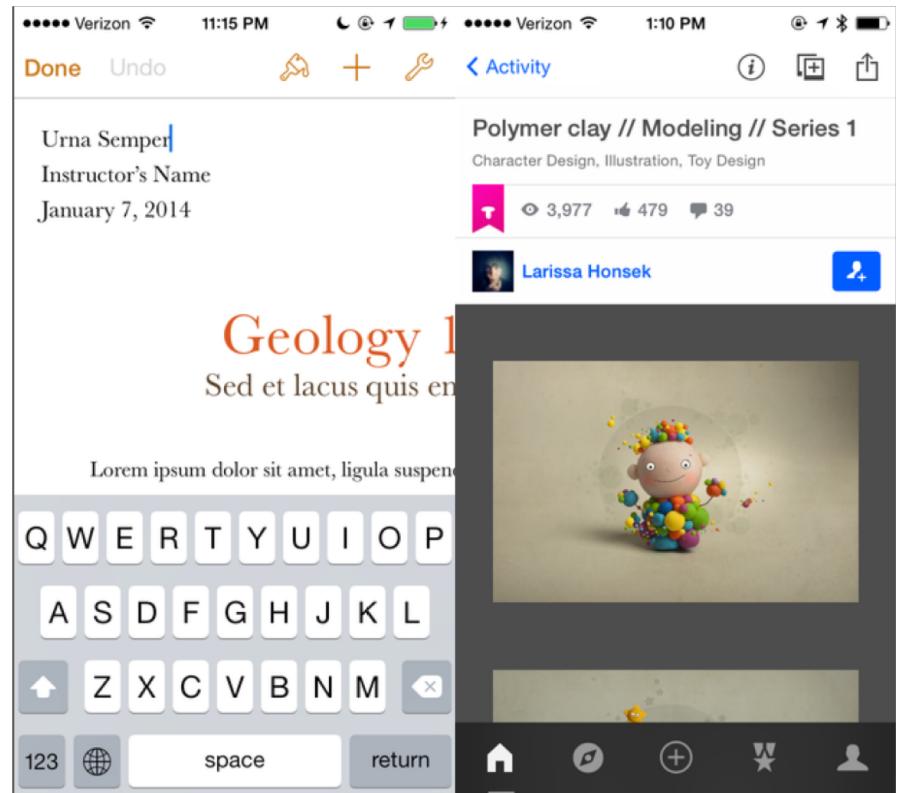
“Mobile UI Design Pattern” (Bank and Zuberi)

Help Users Find Correct Actions

Highlight New Content

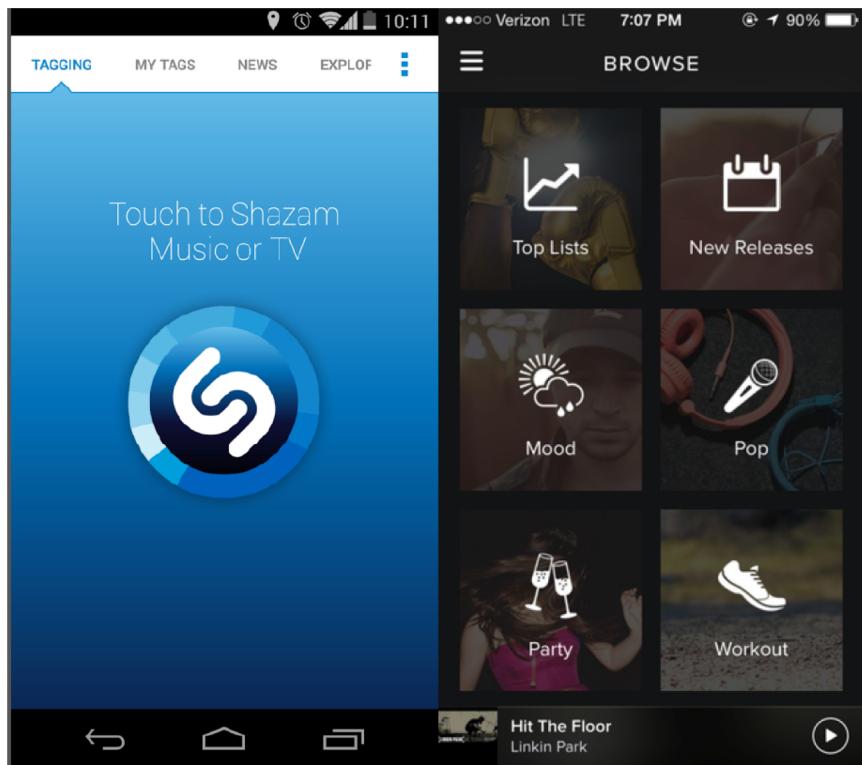


Quick Access to Frequent Actions

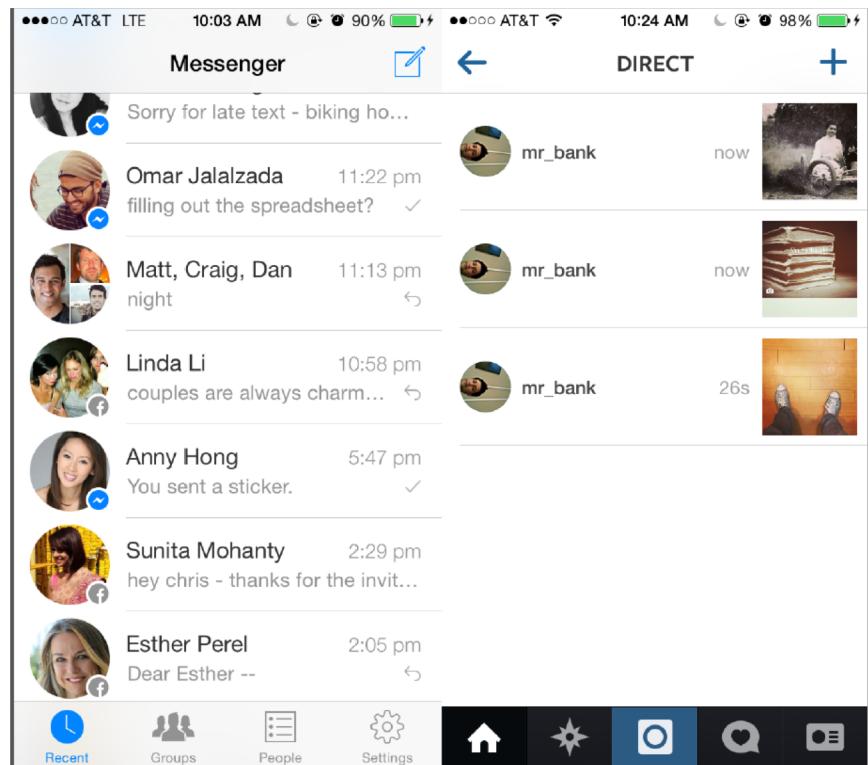


Tip: Help Users Find Correct Actions

Make Actions Obvious

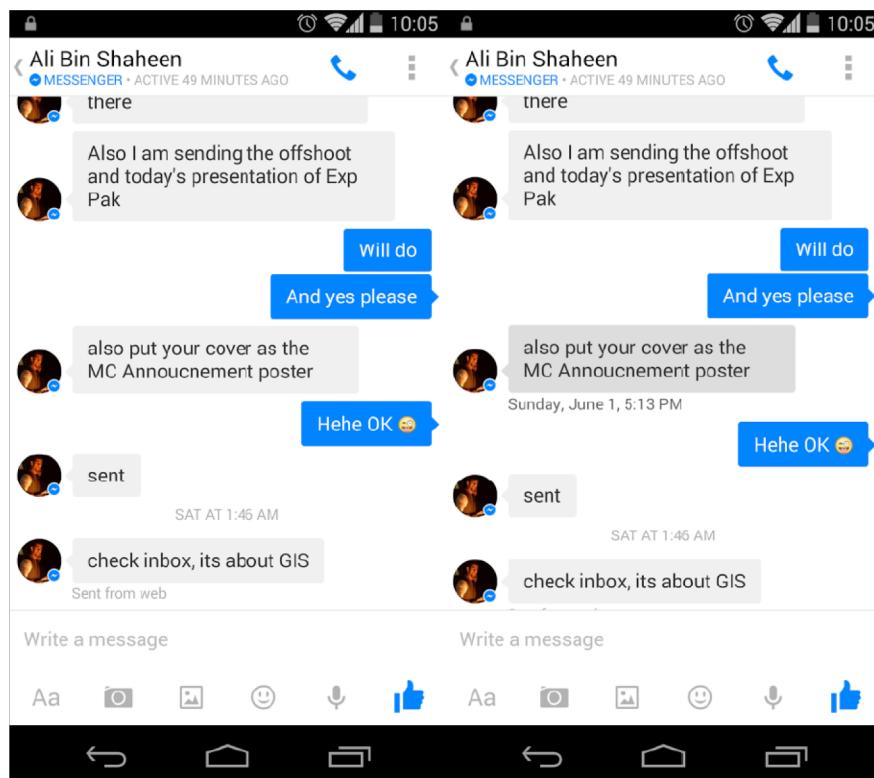


Distinguish Between Controls and Content



Avoid Clutter

Hide Meta Data



Hide Secondary Menus

