New Developments
In Touch Technologies

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Agenda

- Introduction
  1. Projected Capacitive
  2. Vision-Based
  3. Camera-Based Optical
  4. In-Cell, On-Cell & Out-Cell
  5. Infrared
  6. Analog & Digital Multi-Touch Resistive (AMR & DMR)
  7. Surface Acoustic Wave (SAW)
A Simple Touch Isn’t Simple…1

- Touch classification from the University of Toronto

Example: iPhone/iPad

- Sensed Objects
  - Stylus
    - None
    - Recognized Differentiated
  - Imagery
    - None
    - Text/Graphics Fingerprints

- Sensed Information
  - Contact Differentiation
    - None
    - Partial
    - User
    - Total
  - Hover
    - None
    - Stylus Only
    - 1-Bit
    - Continuous
  - Contact Data
    - Line/Intersection Point
    - Bounding/Approximation Geometry
  - Contact Pressure
    - None
    - Stylus Only
    - 1-Bit
    - 3-Bit
    - Continuous

Source: Daniel Wigdor
A Simple Touch Isn’t Simple…2

- It’s far more complex than just “how many touches?”

The Breadth vs. Depth Problem

- Design software once for common capabilities
  (wide breadth, limited functionality)

- Re-design software for each platform’s capabilities
  (narrow breadth, deep functionality)
Projected capacitive has become mainstream

- In 2006 (pre-iPhone), total worldwide sales of pro-cap were approximately $20M
- According to DisplaySearch, pro-cap is estimated to be $2.8B in 2010 (CAGR = 244%)
  - According to DigiTimes, the largest single supplier in 2010 (TPK Touch Solutions) was over $1B

Mobile phones & tablets are driving the market

- 50% of the $2.8B in 2010 was mobile phones (DisplaySearch)
- 30% was Mini-Note PC/Tablet
- 14% was MP3(music) / PMP(media) / PND (navigation)
Projected Capacitive…2

- Capacity is expanding extremely rapidly
  - TPK, Wintek, CMI, Cando, Sintek, Young Fast, AUO, CPT, etc. are all adding glass-type pro-cap capacity (mostly 2.5G – 5.3G)

- Construction is stabilizing
  - Film-type for mobile phones
  - Glass-type for larger products (e.g., iPad)
    - “One-glass” (touch on underside of cover lens) is the current industry trend

Source: Sony Chemical
**Usable stylus is almost here**

- Atmel, Cypress, Maxim (controller-IC suppliers) are all saying they can support a conductive stylus with **1-mm tip**
- Higher signal-to-noise-ratio (SNR) controllers are enabling this

**Capacitance Profiles**

- 2-mm stylus on 4” screen with high-SNR controller
- Same stylus and screen with low-SNR controller

Source: Maxim
Hitachi’s claimed “non-conductive pro-cap stylus”

- Shown at FPD International in Japan (November 2010)
- Probably is a combination of pro-cap and voltage-sensing in-cell (pressure-sensitive) touch, NOT just pro-cap

Source: Photo by author
The maximum size has expanded to 32”

- 3M & TPK/MasTouch have 32” pro-cap monitors
- Asus has a 27” pro-cap all-in-one touch computer (ET2700)

- High-volume cost is $3/inch
Performance is increasing

- Consumers don’t want to wait for the touch system!
- 3M is the current champion with 40+ touches on 22” pro-cap monitor at 200 samples/second/touch (5 ms)

Source: Photo by author
Microsoft/Samsung announced **Surface v2** at CES 2011

Document on surface

Source: Microsoft

4” thick

Source: TechCrunch.com
What is Surface v2?

- “Connects people to information and each other” (Microsoft)
- 40” full-HD (1920x1080) Samsung LCD (55 ppi)
  - 4” thickness includes 2.9 GHz PC with embedded 64-bit Win-7
- Corning Gorilla Glass bonded to LCD
  - Display still has some bezel height (not a flush surface)
- **In-cell touch:** 1 light-sensor per pixel = 2M sensors
  - By far the most sophisticated in-cell light-sensing so far
  - Half of sensors are IR; other half are visible-light (unclear why)
  - RGB pixels may be modified to reduce effect on aperture ratio
  - IR light source is probably added to backlight (uncertain)
- 50+ simultaneous touch points
  - Surface image-processing software is primary Microsoft value-add
- $7,600 – targeted at enterprise
The number of “touch tables” is rapidly increasing

Source: Google Image Search
Why does vision-based touch matter?

- It’s the only touch technology that can do true object-recognition which…

- Enables integrating the physical world and the virtual (digital) world more closely which…

- Makes digital information more easily accessible when users interact with a physical object

Which has more potential to change the world, projected capacitive or vision-based touch?
Camera-based optical is starting to mature

- Windows 7 on all-in-one (AiO) desktops is #1 volume
  - Optical hits the sweet spot of price and performance compared with other touch technologies for all-in-ones
  - Almost all desktop PC OEMs & ODMs are using optical

Large-format (> 30”) camera-based optical is growing

- Key applications
  - Interactive information
  - Interactive digital signage
  - Education (including opaque & LCD interactive whiteboards)
Two touches with two cameras (current market focus) has two main limitations:

- Ghost touches
- Occlusions

The quality of the touch experience depends on the sophistication of the algorithms that handle ghost touches and occlusions.
● **Products with 3 cameras**
  - Adding a *third camera* doesn’t actually improve the touch quality very much because there are still ghost touches and occlusions.
  - Using *four cameras* eliminates essentially all of these problems, but most PC OEMs perceive that two-camera performance is “good enough” and aren’t willing to pay for four cameras.

Dell ST2220T Touch Monitor with 3 cameras
In-Cell, On-Cell & Out-Cell…

 Definitions

- **In-cell:** Touch sensor is inside the LCD cell, between the two sheets of glass
- **On-cell:** Touch sensor is on top of the color filter glass, underneath the polarizer
- **Out-cell:** Touch sensor is on top of the LCD (normal)

 Technologies

<table>
<thead>
<tr>
<th>Touch Technology</th>
<th>Location</th>
<th>Status</th>
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<tbody>
<tr>
<td>Light-sensing</td>
<td>In-cell</td>
<td>Difficult technical problems; see Surface v2</td>
</tr>
<tr>
<td>Voltage-sensing</td>
<td>In-cell</td>
<td>Used only in hybrid combinations</td>
</tr>
<tr>
<td>Charge-sensing (projected capacitive)</td>
<td>In-cell &amp; on-cell</td>
<td>Limited success in-cell; strong success on-cell (products in the pipeline)</td>
</tr>
<tr>
<td>Hybrid voltage-sensing &amp; charge-sensing</td>
<td>In-cell</td>
<td>A few products on the market (e.g., digital cameras)</td>
</tr>
<tr>
<td>All other technologies</td>
<td>Out-cell</td>
<td>Business as usual</td>
</tr>
</tbody>
</table>
In-Cell, On-Cell & Out-Cell...2

First product with in-cell (hybrid) touch (April 2009)

First product with optical in-cell touch (May 2009)

2nd-gen camera with hybrid in-cell touch (August 2009)

First OLED product with on-cell touch (Feb 2010)

Largest (13.3”) on-cell finger-touch (charge-sensing) product so far (Feb 2010)
Special case: Integrated Digital Technologies, Inc.

- 21.5” light-sensing in-cell monitor with IR light-pen
- Supports two-touch with two pens

Source: IDTI

Source: Photo by author
Out-Cell Projected Capacitive

CPT 21.5”
2 touches

AUO 32”
10 touches

Source: Photos by author
Multi-touch in traditional infrared

- 2+ touches
- Suppliers: IRTouch, Groovy Touch, Leading Touch, etc.
- "Ghost" points are the problem, and there's no good solution
Infrared...2

- Multi-touch in “LED Cell Imaging” infrared
  - 20-30 touches
  - Suppliers: PQ Labs, Citron

- Issues: Relatively low resolution and slow response time

Source: PQ Labs

Source: Author
Infrared in mobile devices

- Neonode cellphone (2009)
  Source: Pen Computing

- RPO *waveguide infrared* in prototype 13.3” notebook from LG Displays (2010)
  Source: Photos by author

  Source: PC World

- RPO in Mirasol screen (2010)
Analog & Digital Multi-Touch Resistive (AMR & DMR)…1

- Both are alternatives to projected capacitive
  - Familiar resistive technology
  - Patterned ITO (like pro-cap) instead of single-touch resistive’s continuous ITO
  - Lower cost

- But, both have standard resistive shortcomings
  - Low durability (PET top surface)
  - Low transmissivity
  - Non-zero touch force
Analog & Digital Multi-Touch Resistive (AMR & DMR)…2

- **AMR** (also called “hybrid analog-digital”)
  - Suppliers: eTurboTouch, Mildex, Mutto, EETI, ATouch…
  - Limited IP on concept
  - Number of touch points is controller-dependent (2-10)
  - Offered in 3” – 23”, but not actually in production in all sizes
  - Can’t touch with two fingers on the same square

Source: Author
Analog & Digital Multi-Touch
Resistive (AMR & DMR)...

Gateway ZX6910 AiO with 23” AMR touchscreen from eTurboTouch

“There is no perfect touch technology”
DMR (also called “digital matrix resistive”)

- Stantum (in France) is primary IP holder
- Stantum’s strategy is to license controller IP to IC manufacturers
  - Sitronix
  - ST Micro
- Unlimited number of touch points
- Aimed at phones and netbooks
- Fine pitch results in much higher number of connections than AMR
  - 64 x 36 = 100 on 4.3” screen
Surface Acoustic Wave (SAW) ... 1

How two touches are supported by SAW

Surface Acoustic Wave (SAW)…2

❖ Multi-touch SAW from Elo/Tyco Electronics
  ✦ Shipping in the 23” Lenovo A700 all-in-one desktop

“There is no perfect touch technology”

Source: Lenovo

Source: Photos by author
Elo/Tyco Electronics’ “zero-bezel” (flush) SAW
Conclusions

1: “Change is the only constant” (especially in touch!)

2: “There is no perfect touch technology”
Thank You!

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