BEYOND TOUCH: INTRODUCING ADVANCED UI FEATURES

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Improving the user experience is one of the driving forces behind innovations in touchscreen technology. The introduction of projected capacitance touchscreen devices from the older resistive style opened up a new world of options and a vastly improved interface for users. Projected capacitive technology enables unlimited multitouch interfaces with gesturing for a smooth and seamless user experience. Mobile device manufacturers have recognized the benefits to a user interface (UI) powered by capacitive touch, and most handheld devices deliver touch performance at a level that would have been unthinkable just a few years ago. Now, engineers and developers focus on faster response times, better accuracy, and higher signal-to-noise ratios (SNR) to provide a more innovative user experience (UX) in their products.

But touchscreens need more than just touch to stand out. Delivering a better user experience means providing advanced features that solve known problems and help to make these devices easier and more intuitive to operate for the end consumer. It also helps manufacturers differentiate their products in an increasingly crowded and competitive market. What kind of features could provide that kind of experience? What issues have consumers been asking device makers to solve? Three capabilities trending in today’s market are support for a resistive stylus replacement (RSR), waterproofing, and hover functionality. Some of these features have already started to appear in mobile devices, and are providing real world benefits to the end user. By incorporating these features into their handsets, OEMs can deliver a truly advanced UI – one that goes beyond just touch.

Stylus support is not exactly new to capacitive touchscreens, but the problem with the vast majority of current technology is that the sensor can only read input from a big, bulky device that mimics the size and capacitance of a finger. The controller won’t register input from anything smaller than a touch. The large form factor of these styli make it impossible to clearly see your input on the screen, so completing delicate tasks, manipulating detailed navigation interfaces, or writing in script or Asian character sets becomes very difficult and increases the likelihood of error. Consumers don’t want to be forced to use a thick, clunky stylus like those currently available for use with today’s capacitive touch phones – they want the accuracy and slim form factor of a resistive-style 1 mm tip stylus. Most touchscreen controllers currently support stylus sizes at a 3mm tip and larger, making accuracy and portability difficult, if not impossible, to achieve. Figure 1 illustrates the difference in functionality with an actual, side-by-side comparison of a resistive style, 1 mm tip stylus, and a traditional capacitive stylus. It’s easy to see how the smaller stylus makes detailed tasks easier to complete with its slim form factor and tiny tip.

Waterproofing capability addresses a very real need in a user’s daily life. In the real world, we use our devices in the rain, with wet or sweaty fingers, or in humid environments that cause condensation; and we want the touchscreen to work properly in all of these conditions. However, water on the surface of a touchscreen can significantly impact performance in a variety of ways, from creating phantom touches to impacting accuracy. In some products, water can irreversibly corrupt the mutual capacitance system, requiring a hard reboot. It can even make the screen freeze or become completely non-responsive when a user tries to wipe it clean of water. Fully waterproof devices like digital cameras and even some mobile phones – ones that can be operated even while totally immersed in water – are already starting to appear on the market in limited quantities, and
manufacturers need to stay competitive if they are to increase or even keep market share. The ability to design truly waterproof devices that meet IP-67 standards provides users with an unmatched level of robustness, and allows OEMs to keep up with this market trend.

Hover capability is on the cutting edge of touchscreen technology. The importance of hover is rising quickly among major operating systems, and all current indicators point to this function becoming a major market trend in the next year or two. Hover enables real performance with heavy gloves, or long fingernails – two problems that have been historically difficult to solve for touchscreen manufacturers. Because the capacitance of a finger decreases in proportion to its distance from the sensor, it is difficult to detect the position of a finger through layers of fabric or at the greater distances enforced by long fingernails. Hover solves this issue by being able to accurately and consistently detect the position of hovering fingers, and other objects, even with 10 mm of glove insulation.

Mouseover capability can be designed into handsets using hover for a user to magnify parts of the screen, like hyperlinks or keys on an on-screen keyboard, by hovering over them, then using a direct input device for precise selection. That kind of function also has implications for portable media players, such as previewing a song or a video trailer by hovering over the title before direct selection; or mobile gaming applications, by enabling entirely new features and commands that can be launched via hover input. Additionally, mobile device manufacturers are already working to incorporate emerging 3D display technologies in handsets. Here, hover could allow you to navigate through multiple open applications on a 3D display. Users could bring different applications to the forefront of the screen, while other open applications are still visible behind it. As this type of display becomes more prevalent, hover will enable users to effectively manipulate screen elements for a whole new world of functionality.

So how can you design all of these elements into a touchscreen device? Most touchscreens today use mutual capacitance sensing to detect touch input. Mutual capacitance touchscreens measure capacitance through the intersections of the horizontal and vertical sensor axes (X*Y) instead of as individual sensor lines (X+Y). Because this type of measurement dramatically increases the possible number of sensors on a panel – a potential of 240 intersections, as opposed to 32 sensor lines for self capacitance – mutual capacitance scanning can deliver higher accuracy and true multitouch capability. Figure 2 shows five fingers on a mutual capacitance touchscreen. All five input points are clearly identified, with no positional ambiguity.
But when it comes to advanced features like waterproofing, small stylus support, and hover, mutual capacitance just isn’t enough. Why can’t all multitouch touchscreen devices support these kinds of features, you may ask. It’s an issue of capacitance. Capacitance is defined as the ratio of charge to potential on an electrode. The algorithms in touchscreen controllers that only support mutual capacitance essentially get confused when there’s water on the touchscreen, due to its capacitance. The sensor struggles to properly identify and track touch input in the presence of water, resulting in a high incidence of phantom touches, significantly degraded accuracy, and in some cases complete screen freezes.

Capacitance is directly proportional to the input area. In the cases of stylus and hover support, the capacitance change incurred by a small stylus tip or a finger hovering above the screen isn’t large enough to register as a touch on most touchscreen controllers. Some chip manufacturers that only support mutual capacitance claim to be able to support these features. But when these companies try to show this kind of functionality to customers, most of them use demo kits with significantly increased sensitivity and much lower noise thresholds. In a demonstration, these features may appear to work perfectly. But a demo kit is a safe, noise-free environment, devoid of closely coupled transceivers, LCD screens, USB chargers, and other sources of interference that hinder a touch panel solution’s performance. In an actual device, noise is a nearly unavoidable occurrence. Once you take small stylus support or hover technology and build it into a system where noise is present, the lowered thresholds and increased sensitivity that allowed these features to work in a demonstration now makes the controller susceptible to false touch readings and declining accuracy when noise spikes occur. (see Fig. 3) Those advanced features that worked so well on the demo kit start to fall apart in real systems. Using mutual capacitance measurements alone clearly doesn’t provide enough information for the touchscreen system to support advanced features like waterproofing, support for a small stylus, and hover.

**Fig. 2.** Mutual capacitance sensors have a greater ability to accurately sense multiple input points by measuring the intersection of X and Y sensor lines, instead of the lines themselves. All five fingers are clearly identified on the sensor grid.
Self capacitance, on the other hand, is a very robust method of sensing in many ways. It generates a stronger signal and is capable of projecting larger fields than mutual capacitance. This increased strength and projection ability enables the touchscreen controller to accurately pick up the capacitance of objects like a finger hovering over the screen. Self capacitance can also provide more touch sensitivity without lowering the noise threshold. That gives it a greater ability to sense very small touches, like those from a stylus with a 1mm tip, and makes it far less susceptible to false touches, poor accuracy, and delayed response times than mutual capacitance. But for all its benefits, the problem with self capacitance is that it is not ideal for multitouch functionality. This is because of an issue known as ghosting, where there is ambiguity in the position of the two fingers of a screen. In self capacitance sensing, input is measured for change along the horizontal and vertical axes (X+Y). This results in positional ambiguity if the user touches two places on the same line. Resolving this problem becomes impossible with a third touch. Figure 4 is an example of this kind of ambiguity in a self capacitance touchscreen. The red circles are actual touches on the X and Y sensor lines. Because each line now reads a touch, the intersection of those lines register touches (marked in light blue) as well, even though none are present.
As today’s operating systems support four fingers and beyond, true ghost-free multitouch is required in smartphones. The market already expects and demands full multitouch functionality and gesture recognition in touchscreen devices. Self capacitance sensing just isn’t going to be enough.

How can this problem be solved, then? For a device maker, providing advanced features to the consumer market is crucial for differentiating products from the competition, but it is difficult to implement using only one method of sensing. The best course of action is to use a touchscreen controller that incorporates both self and mutual capacitance sensing. This allows designers to take advantage of the best features of each sense method to deliver truly unique capabilities. Some chip manufacturers use two different chips—one for self capacitance and one for mutual capacitance. But what device manufacturers really need is a touchscreen controller capable of providing both self and mutual capacitance sensing on the same chip, with the ability to switch between both methods while in application. Using differential signal analysis, as this type of controller does, allows manufacturers to deliver real waterproofing, small stylus support, and hover to the market.

Overall, indicators of touchscreen performance like response times, refresh rates, and accuracy, are important; but they are not the only measures by which the user evaluates their experience. Advanced features elevate the quality of the user experience with a touchscreen device. When designing a UI, three features that customers want and need in their handsets are support for 1mm stylus; true waterproofing capability; and hover functionality. These features can be challenging to provide through one method of sensing alone, and many demonstrations are done in a controlled environment. Using a touchscreen controller than delivers self and mutual capacitance on the same chip, with the ability to actively switch between the two, ensures real-world performance for these kinds of advanced features. It also keeps materials cost and device size down by eliminating the need for a second chip. The result is a device with features that raise the standard for UIs and allows manufacturers the opportunity to set their products apart from the competition.