White paper

User study on multitouch in the industrial environment

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Introduction

We use projected capacitive touchscreens and the associated multitouch function on a daily basis on our smartphones, tablets, and notebooks. However, to date, multitouch has only played a minor role on operator panels for machines and systems. Here, simple monitors or resistive touch displays without multitouch support are primarily used. We have carried out a study to analyze why multitouch displays are still only used to a limited extent in the industry. In addition to the reasons for low uptake, we also point out potential uses and use cases and offer recommendations for successful use of future multitouch systems.

1. Market situation and state of the art

Man-machine interfaces of technical systems are often also optimized as part of Industrie 4.0 projects in order to better accommodate the user's wishes and requirements in the operating environment. Modern operator panels should provide a positive user experience, which also includes positive perception of the operator panel by the user as well as a high level of usability.

Touch panels, in particular, are now established in the industrial environment as they can be used for diverse applications. They are used to enter data into machine control systems and observe processes. Fields such as processing and production, energy and environment, building automation, water and wastewater management along with infrastructure and logistics are an ideal match for this technology.

For many years, system manufacturers and mechanical engineers have relied on the proven technology of resistive touch panels. The technology is based on two transparent, metallic films which are positioned over the display itself. The films only make contact when the user presses part of the display. Electronic measuring equipment can determine the exact position from this contact. However, with this technology, only one contact point on the touchscreen can be detected at any one time.

Most users know how to use multitouch technology, which is used in the majority of smartphones. This is now also driving the use of multitouch devices in the industrial environment. This trend is becoming increasingly evident at trade fairs and exhibitions. Visitors to trade fairs instinctively try to use familiar gestures from their smartphones on the touchscreens. They often seem bewildered when industrial devices do not support these functions. Also, a growing number of articles in specialist automation technology and industrial electronics magazines are covering the topic of multitouch (see, for example [1] and [2]).

The “Multitouch in the industry” [3] study already investigated multitouch operating concepts for industrial use in 2012. As a result, the operating principle with just one contact point was called an “outdated single-touch model”. It was also postulated that multitouch would break through in the future, as it is backwards compatible with single-touch but offers even more interaction options [3].

Given this stated demand for multitouch-capable control panels, manufacturers, including Phoenix Contact, have extended their product portfolios accordingly. Since 2013, the company has also offered operator panels based on the projected capacitive touch concept.

Yet their use in machines and systems is still subject to huge challenges and the technology continues to play a minor role in the industrial environment. Here, simple monitors and resistive touch displays without multitouch support continue to be the main players. In practice, projected capacitive touchscreens are still rare.

Figure 1
Interaction with a multitouch panel

In this article, we present the results of a study designed to analyze the reasons for the discrepancy between assumed and real demand for multitouch displays. Furthermore, we consider the use cases that exist for multitouch in the industrial environment.

2. Limitations of multitouch and common operating concepts

Manufacturers use a variety of technologies for touch displays. Whether they are resistive, capacitive or make use of infrared sensors, the methods are numerous. However, not all these methods support the multitouch function. This means an operator panel which can detect two or more points of contact on the display surface at the same time (see table 1).

Method	Functional principle	Contact points	Comments
Resistive touch	Pressure-based contact between two transparent films positioned over the display	max. 1	Can be operated when wearing gloves
Projected capacitive touchscreen (PCAP)	Detection of conductive objects which touch the touchscreen, via capacitive coupling	max. 10	Limited operation when wearing gloves
Infrared curtain	Infrared light barriers above the display which are interrupted when the display is touched	max. 2	Limited by masking effects
Diffused illumination	Camera-aided monitoring of the display surface	Practically any	Sensitive to daylight

Table 1
Example touch technologies at a glance [4]

3. Study design

In order to analyze the discrepancy between assumed and real demand for multitouch displays in the industrial environment, we have carried out a two-part study. In the first part, we asked customers of Phoenix Contact Deutschland GmbH to complete an online survey about their perception of multitouch technology in the industry with regard to usability. In the second part, in-depth guided interviews were carried out with nine selected representatives from different industries, in order to analyze future applications fields.

3.1. Part 1: online survey

A target group with a four-figure number of contacts from the field of automation technology were asked their opinion via e-mail. The questionnaire was aimed at customers of Phoenix Contact Deutschland GmbH. It was primarily intended for customers who work in machine building and systems manufacturing. Completion of the questionnaire was voluntary. The contacts were given two weeks to complete it. During this period, around 1% of those invited took part in the online survey. Despite the low participation rate, it has provided us with some insightful initial findings.

The online survey covered the topics of external influences, current use of displays, use of multitouch, perceived importance of multitouch for industry, willingness to invest, and desirable gestures. For each topic, participants had to either answer questions in their own words or assess statements on a 4-point scale.

3.2. Part 2: guided interviews

We also carried out in-depth guided interviews with nine selected representatives from the stated industries. In doing so, we made sure that the interviewees were from different industries and different roles. The interviews were used to analyze requirements placed on industrial operator panels and to discuss potential use cases. The participants of the guided interviews are listed in table 2.

ID	Job title/role	Industry
ASP1	Product management	Machine building/logistics facilities
ASP2	Industry management/projects	Process technology and process engineering
ASP3	Software engineer for control panels	Machine building
ASP4	Workshop managers	Electronics production
ASP5	Group leader, storage planning	Logistics
ASP6	Sales engineer	Machine building/food
ASP7	Machine operator	Production
ASP8	Workshop managers	Production
ASP9	Sales representative	Water/wastewater management

Table 2

Contacts for the guided interviews

4. Results of the study

4.1. Part 1: results of the online survey

The results of the online survey are explained below by topic.

Contamination, light irradiation, and vibrations are frequent influences on machines

First of all, the ambient conditions must be taken into account with regard to the use of multitouch panels on machines and systems. It must be possible to operate the panel without any restrictions or dangers despite interference.

The following factors were often stated as influences on the machine and system: contamination (66.7%), vibrations (60.0%), and direct light irradiation (46.7%) (see figure 2). In one case, the respondent also mentioned that coolant mist arises during processing. Furthermore, another mentioned a high level of humidity. Both are specific atmospheric influences. The participants rarely mentioned spray water (20.0%) as an interfering factor on their machines.

The use of gloves is another aspect that must be considered, this was mentioned by around one third (38.0%) of those surveyed.

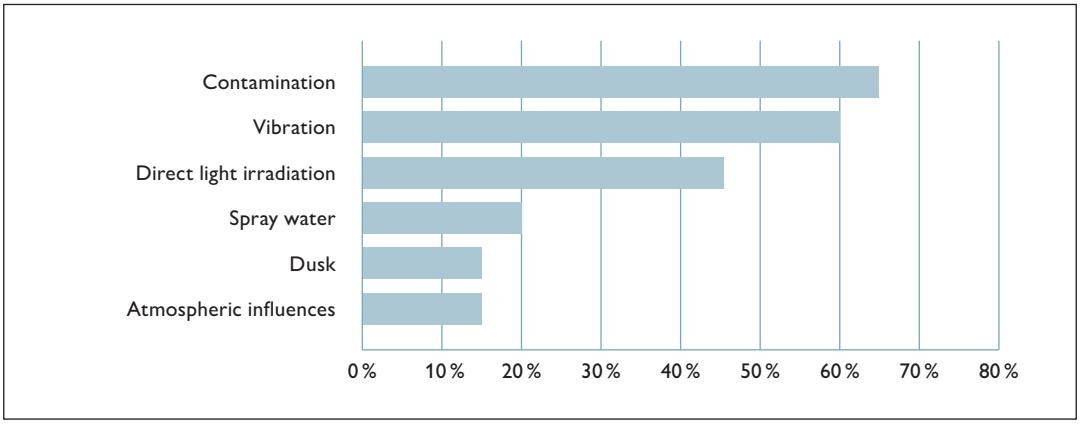

Figure 2
Special influences on machines and systems

Regular operation and monitoring is typical

Almost all the stated applications (85.7%) require operation and monitoring of processes. Normally the process or state of the machine is observed several times an hour. Typical information that is investigated during operation: process and state data (73.3%), event and fault messages (33.3%), details of the production order (33.3%), curves or other methods of error analysis (13.3%) and test instructions (6.7%) provided by the system.

Starting and stopping processes (46.7%) is typically part of the interaction. In addition, target values (60.0%) need to be entered in the system. This includes setting drive speeds, rotary speeds, and special process data such as gas or oxygen pressure, and machine setup. Less frequently, individual states, such as opening and closing of doors in a power station, are also changed.

The operating concepts of the multitouch display are not currently used

With the exception of maintenance measures for machines and systems, manual intervention in the process is rare (13.3%). Haptic buttons and switches (60.0%) are most frequently used. In contrast, a mouse and keyboard (20.0%) and foot pedals (6.7%) are used far less and modern forms of interaction such as voice control and gesture control, along with joysticks, are not mentioned at all (see figure 3).

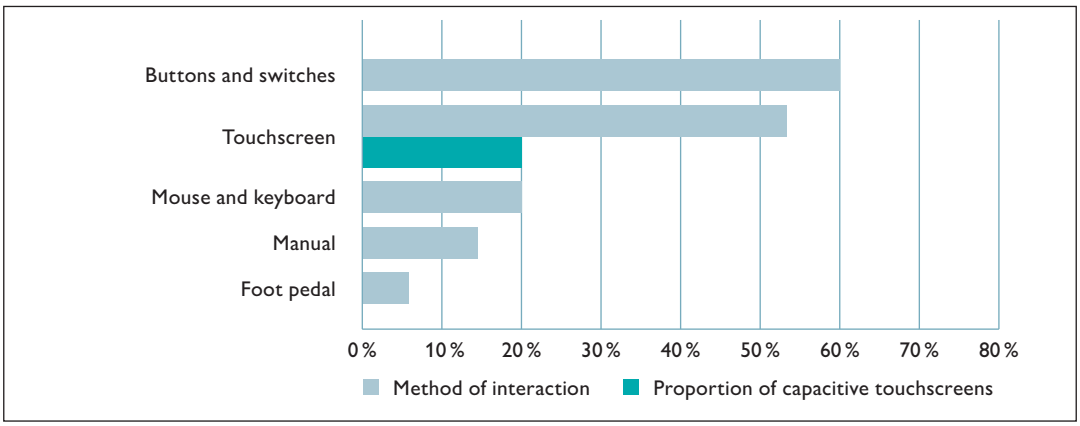

Figure 3
Methods of interaction used

More than half the participants indicated that touchscreens are used on their machines (53.3%). Of those, some also use multitouch panels (20.0%). However, none of those surveyed currently use the multitouch gestures made possible by this technology.

Nonetheless, multitouch seems to be increasing in importance

Those surveyed gave very different responses when asked to what extent multitouch is currently an alternative for customers. As a result, the statements are distributed relatively evenly across the possible answers. However, it is worth noting that few people indicate strong agreement (13.3%) Agreement with the use of multitouch technologies increases somewhat with a view to the next five years (agreement: 61.5%) Almost a quarter of those surveyed strongly agreed in this case (23.1%).

The participants agree with the statement that multitouch is suitable for the industry (86.7%) and tend to see added value in the technology (80.0%). However, strong agreement is rare in both cases (see figure 4). Added value is mainly seen in terms of ergonomics (73.3%) and intuitive operation (66.7%). Haptic feedback is important for half of the people (50.0%).

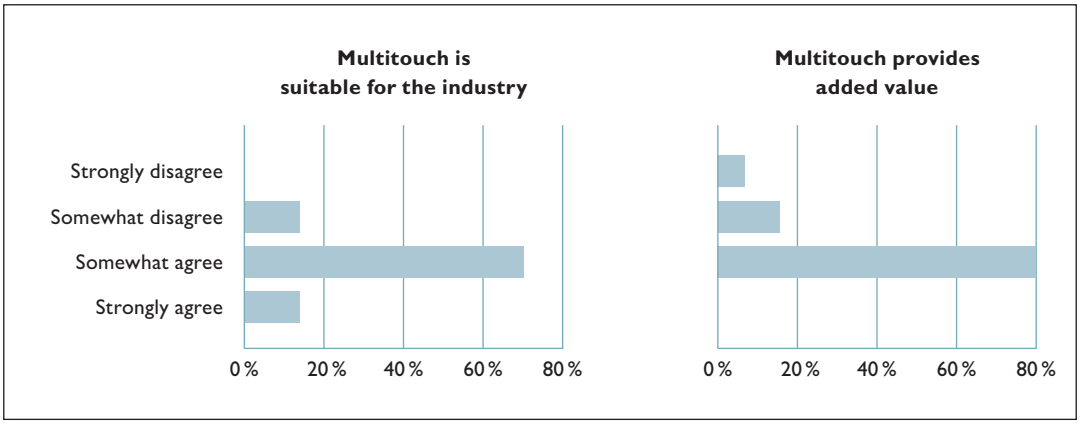

Figure 4
Results of the survey (1)

Participants tend to prefer simple gestures

In addition to entry of numbers (93.3%) and letters (92.9%), the gesture for changing the process screen (85.7%) and for scrolling through long data lists (78.6%) received strong agreement. These are simple swipe gestures. Zooming in, as is used on maps (66.7%), and the associated scrolling in the displayed area (60.0%) is also regarded as a desirable function by many. Zooming with the aim of taking a closer look at 2D or 3D objects was regarded as important by somewhat fewer participants (50.0%).

Little importance is attached to rotation of 2D or 3D elements on machines or systems. This application is not used by the majority of those surveyed. Only a third of the participants agreed somewhat. In total, half of the participants can imagine two-hand operation as a suitable operating concept (55.0%).

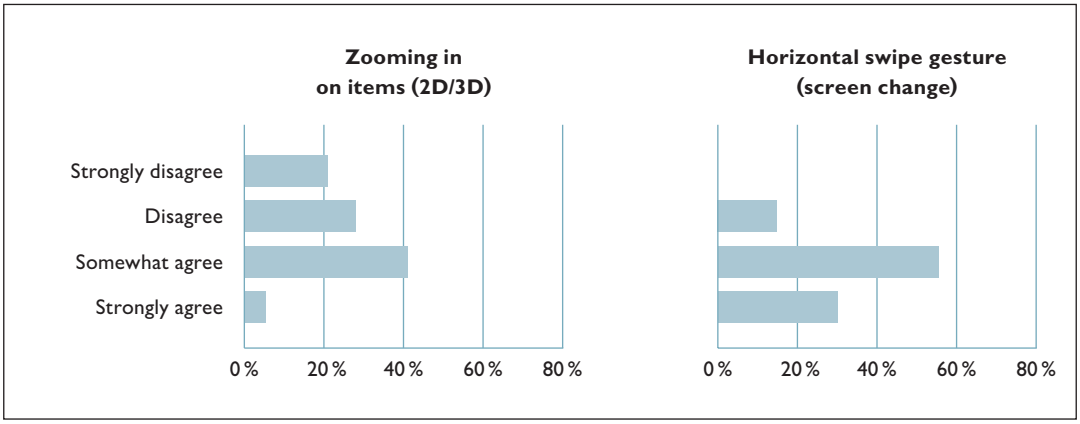

Figure 5
Results of the survey (II)

4.2. Part 2: results of the guided interviews

The guided interviews gave us additional insights, which are presented below.

Existing investments must be recouped first

The majority of guided interviews revealed that the participants are highly interested in the topic of this study and are open to the idea of multitouch. They could easily imagine the technology being implemented in their machines and systems in the future. However, this is associated with a high level of investment which is not always feasible. ASP8 remarked: "We have only recently invested in new touch displays (based on the resistive concept)." The investment in these must first be recouped over the coming years. If measurable benefits of the projected capacitive touch displays were demonstrated, then a switchover would be likely.

Unless there are specific requirements from customers, ASP6's company will not change their system early either. As this particular case concerns special machines, ASP6 regards it as "too great a financial risk to convert the machines on our own initiative."

Multitouch can only be implemented with a great deal of effort and expense

Some participants regard multitouch as a distant utopia. ASP1, among others, does not think there will be demand for multitouch-capable panels in the next ten years. However, the company is considering touchscreens with one contact point. Haptic buttons are currently fitted in the monitor frame.

ASP9 even suspects that use of PCAP technology could pose risks. He fears that "the means will become the end". It is much more disruptive to implement such operating concepts, such as zoom, as they will then result in operating errors. Zooming could result in a view that is difficult to interpret. Thus another function, such as a reset button or additional gesture, would be needed to restore the initial view.

Furthermore, the visualization for the user interfaces would need to be adjusted from the ground up, so that multitouch could be used. ASP9 expects that the outlay for the engineering will be higher, as the individual operating elements and graphics will need to be arranged on the display with sufficient spacing. This is often a barrier for smaller companies. Even training in the use of a suitable software, such as Visual Studio, which ASP3 recommends for visualization of individual display interfaces, takes some time.

"Without multitouch-capable software, you can't completely dispense with the keyboard" stated ASP4, based on their own experience. As the software for machine data recording is not designed for this, it is necessary to use the keyboard every so often. Special key combinations cannot be called up on the on-screen keyboard. In particular, the option to switch between several PCs on one monitor was requested for this application.

The system must provide feedback

ASP4 does not want to do without projected capacitive displays. He reports that employees were initially unhappy with the new touchscreens, as operation at the edge of the monitor was not accurate. Use of higher-quality monitors considerably raised their satisfaction levels. The high touch sensitivity of the capacitive touchscreens is an essential feature and makes work more pleasant for the user.

If an employee touches a resistive touch display, they are often left feeling uncertain as to whether their interaction was recognized by the system. This results in waiting time, possible operating errors, and repeated inputs. ASP8 also observed this kind of dissatisfaction in employees. However, the cause of the long latency time was often due to insufficient hardware processing power (graphics card/processor). If the image takes too long to load, users feel that the process has stopped. Therefore, ASP3 thinks that powerful graphics cards and/or graphics processors are particularly important for implementing multitouch functions.

The traditional button cannot be replaced

Even with capacitive touchscreens, there is still a need for other input devices. So ASP4 believes there is no reason to replace traditional buttons on machines. Here we are talking about buttons used for starting, stopping, acknowledgement, and for carrying out individual steps on the system. All users understand how haptic buttons work. In the event of failure, they are easy and cheap to replace.

5. Identified use cases

The guided interviews gave us insights into possible use cases for multitouch displays, which are presented below.

5.1. Advantages for quality assurance

Quality assurance is extremely important in the industry. As a branch of quality assurance, industrial image processing has enjoyed considerable growth in recent years [5].

Some modern systems record and automatically evaluate images for quality control purposes. To a certain extent, it is also possible, and necessary, for a machine operator to also assess the images or display error characteristic images.

One example of this is a production machine in ASP8's department. One application involves displaying a camera image on a resistive touchscreen. The image has to be enlarged for the operator to observe the structures on it. As ASP8 explains: “Although it is possible to enlarge the image using the resistive touchscreen, it is very tedious.” The stated multitouch gestures would make operation more pleasant in this case.

Another application in the field of quality assurance is the examination of trends and curves. The keys depicted on touchscreens are often used to enlarge and reduce quality curves. Likewise, keys are also shown for navigating the time axis, so that previous values can be examined. It stands to reason that multitouch gestures offer an advantage in terms of time.

5.2. Paper-free production with multitouch

There are further use cases with regard to paper-free production. In addition to the activities carried out directly at the machine, there is also the issue of organizational information which is important for employees. For this reason, ASP4 uses a multitouch-capable monitor for the shift plan on the shop floor. Employees can use either gestures or a “touch pen” to view the Excel file which contains the work schedule for the following week.

Likewise, PDF files which contain information about the current production order are stored in the system. Instead of pressing a button to scroll through PDF files, gestures are used, for example to examine production order data in more detail.

5.3. Quicker overview of a more detailed system

Over the years a trend has made it clear that it is necessary to display ever more details on the user interface. ASP2 has noticed this development in regard to process technology in particular: “In the eighties and nineties not much data was displayed on the small touchscreens that are mounted on the front of control cabinets in this field.” Since then an array of process data, error messages, and an overview of the system have all been added. He sees the increasing complexity as an opportunity for zoom gestures. Several measuring points that are close together would be easier to examine. Likewise, the intuitive scrolling gesture would be suitable for use on longer error, state, and data lists.

Changing the system view with a swipe gesture is also useful for viewing a system more quickly from various perspectives. However, clear menu navigation is a key starting point when it comes to multiple user interfaces, according to ASP3.

5.4. Two-hand operation

From the perspective of the mechanical engineer, two-hand operation via touchscreen appears to be of interest as accidental operation is largely avoidable.

Critical settings can only be made by also pressing a release switch that is part of the application.

It is worth noting that functional safety must be demonstrated for each new or modified machine that is to be brought onto the market. In Europe, this is regulated by the Machinery Directive or DIN EN ISO 13849 for safety of machinery. Whether the residual risk involved with multitouch two-hand operation is acceptably low must be demonstrated on a case-by-case basis.

6. Discussion and interpretation of the results

The results of the study show that multitouch is definitely a relevant topic in the industry at the moment. Although many companies do not perceive any need for multitouch at the moment, there are at least some individual operators of machines and systems who are already using these capacitive touchscreens. However, current implementation attempts do not do multitouch justice. The options offered by the operating concepts are hardly used. Contact involving more than two contact points is generally not needed. Nonetheless, users value simple gestures and the familiar, everyday touch sensitivity of the capacitive touchscreens.

The fact that operation of these devices is restricted with conventional work gloves is only an issue for a few users of the interfaces.

Many mechanical engineers and systems manufacturers go without capacitive touch panels because there is no supporting software. The high costs involved in integrating multitouch functions bear no relation to the expected benefits. These amount to more than just one-off costs for the operator panel. Software engineering is a larger cost factor. Just because the operator panel is multitouch-capable, this does not mean that the software for visualizing the machine data is too. Smaller companies, in particular, have limited options for creating complex visualizations.

In the industrial environment, switching to new technology is associated with financial risk. While end users of personal devices enjoy the opportunity to simply try out a new technology, machine operators do not want to take the added risk. This is tied to uncertainty and fear of possible operating errors, and the risk of placing man and machine in danger. Here, the high level of touch sensitivity is a disadvantage, as accidental liquid spills could also be regarded as an interaction. Users expect efficient and 100% reliable technology.

The use cases depicted show that multitouch can make it easier to monitor states and read extensive data, in particular.

7. Summary and outlook

The results of our study present an ambivalent picture: even though operation using a multitouch display continues to be regarded as a promising interaction technology in the industry, our study shows that there are obstacles to its introduction. First, technical software support must be provided for machine programmers. Without this, new multitouch systems cannot be implemented efficiently. In order to provide added value, user interfaces first need to be adapted to accommodate multitouch. Secondly, the operating error fears associated with interface changes is also hindering the introduction of this new technology.

Some of the users of multitouch displays in our analysis had only recently invested in the new technology. These existing investments must first be recouped over the next few years. If measurable advantages of the projected capacitive touch displays were demonstrated, then widespread changeover would be likely. The few multitouch applications currently in use in the industrial environment are largely tentative attempts to implement a known end user technology without adjusting the graphical user interface itself. However, if the necessary software foundations could be laid to enable programmers to efficiently create user interfaces optimized for multitouch, then interesting new use cases will emerge. Applications can be found in quality assurance, detailed on-site system monitoring or for increasing safety of machinery through implicit two-hand operation.

Based on the results of our study, we assume that multitouch will prevail in the long term, despite the low level of current demand. In particular, mechanical engineers and systems manufacturers who want to play a leading role will not be able to pass up on this technology. The introduction of appropriate software frameworks will unlock new use cases. At the same time, the costs for multitouch technology will fall in the future. As new operating systems which support multitouch (Windows 8/10) gain more ground, we also expect demand to rise considerably. Therefore, it is anticipated that the technology will ultimately prevail in the industrial environment.

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