

Touchless Technologies for Kiosks and Vending Machines

In recent times, the new normal has driven us to explore ways to evolve human interactions with the ubiquitous touch screens. This paper focuses on some touchless technologies that can be used as effective alternatives to traditional touch-screen interfaces.

Authors

Rizwan Hirani
Solutions Engineer

Kuan Heng Lee
Platform Architect

Keywords—touchless technology, gesture, virtual mouse, Deep Learning (DL), Computer Vision (CV), Machine Learning (ML), Contactless Kiosks, Touchless Kiosks, Digital Signage

Abstract

Touch screens are used as human-to-machine interaction devices to present a user interface in the public domain, for a variety of kiosk applications. The new normal has provided us with an opportunity to evolve user interfaces beyond traditional touch screens by deploying various touchless techniques.

These technologies can also be used to retrofit existing touch-based kiosks thereby converting them into touchless ones. This paper focuses on some touchless solutions that can be used in retail outlets like kiosks, vending machines, and point-of-sale devices.

Introduction

Kiosks are very popular and widely deployed in many public applications. They are used for self-check-ins at hotels and airports, for ordering food at quick-service restaurants, for obtaining bus/train/metro/cinema tickets, for obtaining information to find one's way, and so on.

In all these applications the touch screen is used as the primary interface. To prevent the spread of the germs it is essential to use technologies that are not only touchless but also more effective and user-friendly when compared to traditional touch screens.

Some obvious solutions to sanitize traditional touch screens are to manually clean the touch screens frequently or use automatic UV lightings to kill the germs on the screen. The former technique requires additional manpower and recurring maintenance costs while the latter involves adding a costlier electro-mechanical setup (with downtime after each use) to trigger the UV light for disinfecting the touch screen.

Other techniques, such as using a disposable stylus or utilizing the user's hand phone to control the user interface (UI) through QR code scanning, are also available. Using a disposable stylus could be a good solution in the short term but with increased volumes due to increased number of users, the recurring cost can be very high for a long-term implementation. Using the hand phone (or smartphone) to control a kiosk's UI by reading the QR code impairs user experience because of a smaller screen. Added to that are other limitations of dependencies on data network or local Wi-Fi.

Table of Contents

Introduction	1
Short Distance Virtual Touch Using IR/Proximity Sensors	2
Virtual Mouse Using Camera or Radar Sensors	3
Gesture-based Solution Using Computer Vision or Radar	4
Conclusion	5
References	6
Ecosystem Independent Software Vendors	6

Thus, it is essential to find a touchless solution that is not only intuitive but also cost effective and easy to scale. Currently, various emerging touchless technologies are available as potential replacements for touch screens. In this paper, the following technologies are described in terms of their concepts, benefits, drawbacks, and potential use cases:

- Short distance virtual touch using IR/proximity sensors
- Virtual mouse/touch using computer vision or radar
- Gesture solution using computer vision-based deep learning method or radar

Short Distance Virtual Touch Using IR/Proximity Sensors

Proximity sensors are discrete sensors that can detect the presence of nearby objects without any physical contact. Proximity sensing can be achieved using capacitive, inductive, and IR-based techniques. IR-based sensors are already widely used in smartphones: during a call, the phone's touch screen is deactivated when the handset is brought close to the ear to prevent any inadvertent touching of the screen.

The simplest implementation is shown in Figure 1. A 3x3 array of IR-based proximity sensors is connected to the controller/processor over I2C. The detection distance and dwell time are configurable parameters for the sensor by adjusting the bias current. In this configuration, the proximity sensor can act like a switch, and based on preconfigured threshold, it can provide interrupt to host controller for detection of a physical object.

This concept can be used to implement simple non-touch-based touch interface where a user just needs to go close to the sensors rather than touch it. Proximity sensing distance can be configured up to 25-30 millimeters for touchless operations.

A similar solution as shown in Figure 1 can be developed using the inductive coupling method, where you can replace the IR/proximity sensors with PCB traces to form a specific antenna pattern. When the finger is brought near to the traces, it changes the characteristic antenna's transmission line due to coupling with the *mass* of the finger. The ADC (analog-to-digital converter) connected to antenna pattern detects this change and triggers a feedback switch press event to the application processor. A simple matrix keyboard implemented with this

concept can be especially useful in vending machines.

Other solutions are available, where an array of IR transmitters and receivers is placed across the length and width of the screen, like an IR bezel. Such solutions require more sensors and a more complicated AI model to locate the touchpoints when a user hovers a finger over the screen. It can be a costly implementation and is similar to the virtual mouse concept showcased in the next section. The only difference is that it is implemented with IR sensors instead of vision sensors.

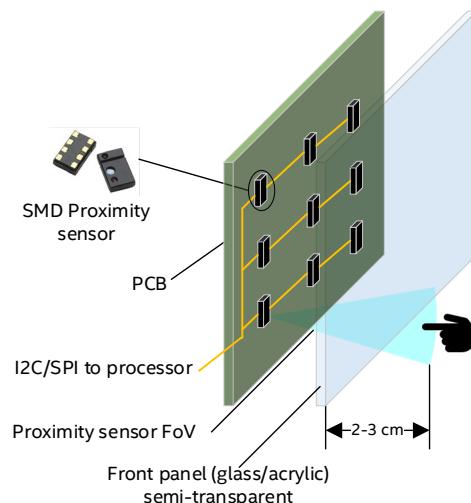


Figure 1. Conceptual non-touch IR proximity sensor-based keypad solution

Advantages

1. Simple implementation to replace traditional buttons
2. Cost-effective solution as proximity sensors or copper traces are very cheap
3. Simple I2C/SPI sensor-based solution makes it easy to develop drivers and SW applications
4. Very low latency operations. These methods require very less processing, and therefore, can achieve latencies in the range of 100-200 milliseconds.

Drawbacks

1. The number of touchpoints or buttons are limited by the number of sensors.
2. The distance of virtual touch cannot be more than few centimeters using low-cost sensors. So, they are not suitable for use cases where the required distance is more than 3-4 centimeters.

Use cases

1. Food or beverage dispensing vending machines
2. Coffee dispensing machines
3. As touchless numerical keypads in ATM and POS devices

Virtual Mouse Using Camera or Radar Sensors

For larger screen displays with an on-screen GUI, a virtual mouse or a virtual touch solution can be a great alternative. In the virtual mouse or virtual touch concept, computer vision is used to track a user's finger to position it on the screen, while pushing the finger towards the screen is configured as a touch event.

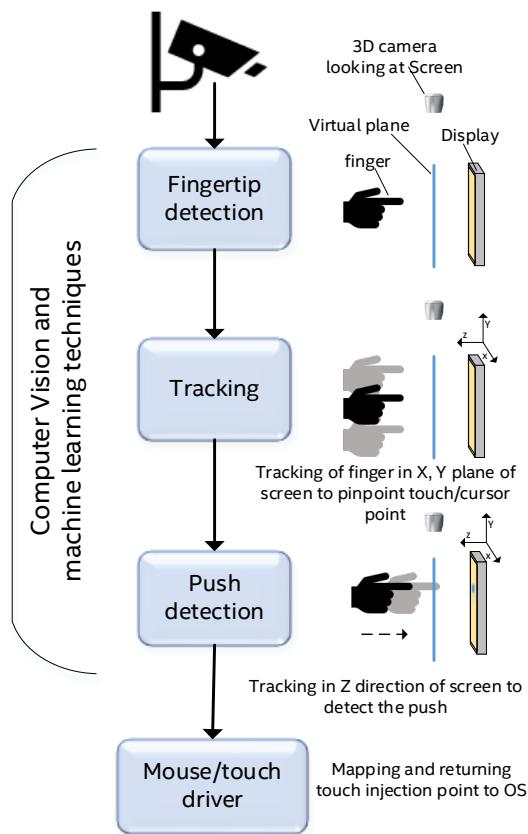


Figure 2. 3D camera-based conceptual virtual mouse implementation using computer vision

3D cameras are most suitable as key building blocks for this concept since they provide a depth map as additional information, whereas a standard 2D camera only contains RGB information.

The depth information is crucial for the computer to understand shape, size, and distance. It also helps in tracking 3D objects moving around in 3D space.

As shown in Figure 2, a typical virtual mouse, or virtual touch interface involves a 3D camera followed by AI (artificial intelligence) pipeline involving machine learning and computer vision. AI models can be trained to detect a user pointing a finger at the screen. Using computer vision techniques, the finger can be traced in the XY plane of the screen to detect where the user is pointing, which is like a mouse movement on the screen.

The virtual plane created at a configurable distance from the screen can be used as a threshold to detect the push movement. A finger pushed beyond this virtual plane is mapped to a mouse click or a touch event.

An appropriate driver running in the computer can return the touch injection point to the Windows* operating system (OS). This kind of implementation may help transition existing applications running on Windows*-based OSes without major changes in the existing application.

In the IoT ecosystem, there are various Independent Software Vendors (ISVs). These ISVs provide the necessary Software Development Kit (SDK) or AI engines to perform the finger tracking and push detection part of this solution.

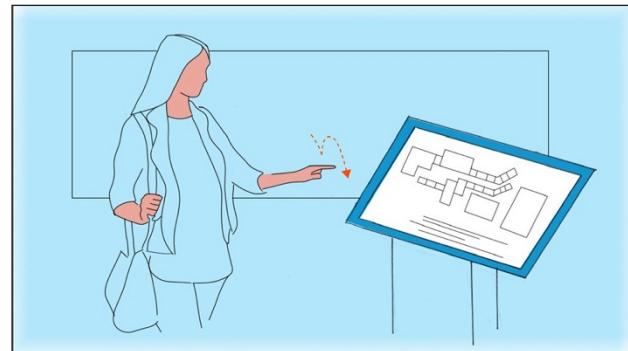


Figure 3. Illustration of virtual touch/mouse usage

A similar virtual touch or virtual mouse can be realized using a low-cost radar solution. A 60 GHz radar transceiver module is small and can be placed on the screen to track the incoming finger from the user. The radar can offer higher accuracy and faster response compared to the camera-based design.[1] However, the AI models involved in this radar solution can be complex and may not be readily available from the broader IoT ecosystem.

Advantages

1. Virtual mouse/touch solution offer as many touchpoints as desired to replace existing touch screens.
2. An easy-to-scale solution with only one additional HW is required (either camera or radar).
3. Easy to retrofit into existing solutions out in the field by just adding a 3D camera to the system (cost-effective solution if radar is used as the capture device instead of a 3D camera).
4. Ecosystem is quite matured with competitive solutions from various ISVs to implement a virtual mouse using their AI models.

Drawbacks

1. 3D camera cost can be higher compared to IR sensors or radars. Outdoor solutions with direct sunlight may require a camera with higher dynamic range to overcome light issues.
2. Can be configured in single-user mode; that is, at a time only one user can interact with the system.
3. ISV ecosystem is still evolving for radar-based low-cost solutions.
4. The placement of camera can be challenging in some cases, considering the field of view of the camera, especially for larger screens.

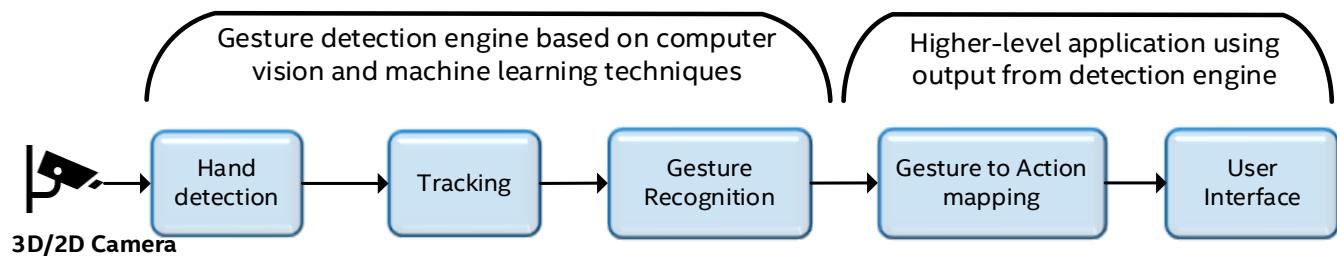


Figure 4. 3D Camera-based gesture detection AI pipeline and application

Use cases

1. Ticketing kiosks at bus stations, metro stations, train stations, cinemas
2. Queue management kiosks at hospitals, banks, and other retail sectors
3. Self-ordering kiosks at fast food restaurants, self-check-in or check-out kiosks at hotels

Gesture-based Solution Using Computer Vision or Radar

Like virtual mouse methods mentioned earlier, computer vision or radar technology can be combined with deep learning network to detect the specific shape of the hand to recognize gestures. AI models can also be trained to detect specific dynamic gestures.

While the key building blocks to detect the gestures are similar to the virtual mouse, the number of shapes and movements to detect are higher here. The output video from the camera is processed to first detect the hand and then track its movement. Tracking the hand gives various movement information.

Common hand gestures easily recognized by machines are the following:

1. OK (first finger and thumb forming an O)
2. Palm swiped up/down/left/right
3. Two fingers swiped left/right
4. Thumb up/down
5. Rotate hand clockwise/anti clockwise
6. Grab action
7. Forming a fist
8. Palm-push action
9. Pinch and Zoom action

ISV partners use different techniques and machine learning algorithms to detect these gestures. Most common are to track the hand at the skeletal level. This method helps in detecting various shapes and position changes.

At the user level, an application is designed to map each gesture to specific actions. For example,

- OK is to *Select*, like touching a specific icon.
- Palm swiped up/down/left/right is to scroll the screen up/down/left/right.
- Two fingers up/down/left/right is to move the cursor up/down/left/right (like the four arrow keys) to select a specific icon.

All user interfaces can use the above three actions to control all possible actions in the kiosks. As of today, there are no industry standards for gestures where specific actions are mapped to specific functions.

However, wider adoption of this technology will lead to possible standardization in the future.

Advantages

1. Gestures are innovative and cool; helps attract more customers in a safe environment.
2. An easy-to-scale solution with only one additional HW is required (either camera or radar).
3. Very effective for larger screens; can allow multi-user configuration (that is, one big screen can interact with more than one customer at a time).
4. Easy to retrofit into existing solutions out in the field simply by deploying an additional camera in the system. The camera can be front-facing and can be utilized for other purposes, such as facial payment and facial recognition¹.
5. Ecosystem is quite matured with competitive solutions from various ISVs to implement gesture recognition.

Drawbacks

1. 3D camera costs are higher compared to IR sensors or radars.
2. No specific industry standards exist; implementation varies per deployment.
3. End user may find it complicated to use gestures, leading to a longer learning curve.
4. Outdoor solutions with direct sunlight may require a camera with higher dynamic range to overcome light issues.

Use cases

1. Informational kiosks with requirements to provide extra information on products and services, where scroll, zoom in/out gestures can be useful
2. Interactive digital signages with larger display, interacting with more than one user at a time (while a virtual mouse can interact with only one user at a time)
3. Entertainment and gaming kiosks
4. Way finding kiosks with additional capabilities to zoom into maps and provide 2D/3D viewing

Conclusion

Touchless solutions are essential for a world adapting to the new normal. The solutions described here can play a vital role in helping people move back to their normal way of life faster.

Intel has strong ecosystem ISV partners who provide the best solutions powered by Intel® Core™ processors to create a safe and healthy environment. All these technologies are not only alternatives to the touch screen but are also more effective and user-friendly in a way that dramatically improves end-user experience.

ABOUT INTEL

You may know us for our processors. But we do so much more. Intel invents at the boundaries of technology to make amazing experiences possible for business and society, and for every person on Earth. By harnessing the capability of the cloud, the ubiquity of the Internet of Things, the latest advances in memory and programmable solutions, our rich portfolio of AI technologies, and the promise of always-on connectivity, Intel is disrupting the retail industry and helping solve the toughest challenges.

Recommended Intel Compute Platforms for contactless kiosks/digital signages are:

- [Intel® Open Pluggable Specification](#)
- [Intel® Smart Display Module](#)
- [Intel® Smart Kiosk Module](#)

¹ Intel is committed to respecting human rights and avoiding complicity in human rights abuses. See Intel's Global Human Rights Principles. Intel's products and software are intended only to be used

in applications that do not cause or contribute to a violation of an internationally recognized human right.

Other recommended Intel Compute Platforms are:

- Intel® NUC
- Mini-ITX motherboards
- Third-party compute platforms based on Intel® Core™ processors

Intel Resources:

- Intel® Distribution of OpenVINO™ Toolkit
- Intel® OpenVINO™ Pre-trained Models
- Intel® Core™ Processors
- Intel® Vision Accelerator Design Products
- Intel® RealSense™ Technology
- Intel® RealSense™ SDK 2.0

References

[1] C. D. Silva, R. Arefi and C. Cordeiro, White Paper: The Need for Enabling Touchless Technologies, Intel, Next Generation & Standards, 2020

Ecosystem Independent Software Vendors

Here are some examples of ecosystem-Independent Software Vendors (ISVs) with touchless solution offerings.

Ecosystem ISV Partner	Description
AMERIA AG ameria.de	Ameria's Connected Experience (CX) touch-free solutions are a way to retrofit existing touch screens measuring up to 43 inches. They turn every screen into an interactive, touch-free screen.
Azkoyen Group azkoyen.com	Azkoyen offers a short distance contactless touch interface panel with 20 selections and backlights to integrate over a serial interface. The solution supports a range of up to two centimeters (2 cm) behind a four millimeter (4 mm) clear glass/plastic.
Funzin Co., Ltd funzin.co.kr	Funzin's contactless kiosk solution – Gesroid – enables user experience involving gesture interactions, without the users even touching the screen or any physical interface.
Gestoos gestoos.com	Gestoos' touchless air gesture and virtual mouse solutions transform any touch screen or digital display monitor into a touch-free interactive experience for short- and medium-range applications.
LIPS Corporation lips-hci.com	LIPS 3D Motion Gesture is a gesture-recognition middleware that recognizes hand gestures for kiosks and other various retail applications.
Nota Incorporated nota.ai	Nota provides an on-device gesture recognition model that can determine user intent through dynamic hand gestures for contactless kiosk operations.
Outdu Mediatech Pvt. Ltd. outdu.com	Outdu offers AI/deep neural network-based video analytics solutions (SW as well as integrated HW+SW products) for gesture interactions.
Ultraleap ultraleap.com	Ultraleap's hand tracking and mid-air haptic technologies allow users to control and feel digital content with their bare hands, without needing them to touch public display units.



By using this document, in addition to any agreements you have with Intel, you accept the terms set forth below.

Third-Party websites: Websites and content may contain user or third party submitted content; such content is not reviewed, approved, or endorsed by Intel and is provided solely as a convenience to our customers and users. Under no circumstances will Intel be liable in any way for any third party submitted or provided content, including, but not limited to, any errors or omissions, or damages of any kind. **ANY MATERIAL DOWNLOADED OR OTHERWISE OBTAINED THROUGH THE USE OF THE THIRD PARTY WEBSITES IS DONE AT YOUR OWN DISCRETION AND RISK AND THAT YOU WILL BE SOLELY RESPONSIBLE FOR ANY DAMAGE TO YOUR COMPUTER SYSTEM OR OTHER DEVICE OR LOSS OF DATA THAT RESULTS FROM THE DOWNLOAD OF ANY SUCH MATERIAL.** You agree that you must evaluate, and bear all risks associated with, the use of any third-party content, including any reliance on the accuracy, completeness, or usefulness of such content. All use of those Web Sites or content is subject to these terms and the terms of use on those websites.

You may not use or facilitate the use of this document in connection with any infringement or other legal analysis concerning Intel products described herein. You agree to grant Intel a non-exclusive, royalty-free license to any patent claim thereafter drafted which includes subject matter disclosed herein.

No license (express or implied, by estoppel or otherwise) to any intellectual property rights is granted by this document.

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software, or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at intel.com.

Intel technologies may require enabled hardware, specific software, or services activation. Check with your system manufacturer or retailer.

The products described may contain design defects or errors known as errata, which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Intel disclaims all express and implied warranties, including without limitation, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement, as well as any warranty arising from course of performance, course of dealing, or usage in trade.

All information provided here is subject to change without notice. Contact your Intel representative to obtain the latest Intel product specifications and roadmaps.

Copies of documents, which have an order number and are referenced in this document may be obtained by calling 1-800-548-4725 or visit www.intel.com/design/literature.htm.

Intel, and the Intel logo, are trademarks of Intel Corporation in the U.S. and/or other countries.

*Other names and brands may be claimed as the property of others.

2020 Intel Corporation. All rights reserved.