Telepresence Interaction by Touching Live Video Images

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ABSTRACT
This paper presents a telepresence interaction framework and system based on touch screen and telepresence robot technologies. The system is composed of a telepresence robot and tele-interactive devices in a remote environment (presence space), the touching live video image user interface (TIUI) used by an operator (user) in an operation space, and wireless network connecting the two spaces. A tele-interactive device refers to a real object with its identification, actuator, and Wireless communication. A telepresence robot is used as the embodiment of an operator to go around in the presence space to actively capture live videos. The TIUI is our new user interface which allows an operator simply uses a pad to access the system anywhere to not only remotely operate the telepresence robot but also interact with a tele-interactive device, just by directly touching its live video image as if him/her to do it in the presence. The preliminary evaluation and demonstration show the efficacy and promising of our framework and system.

AUTHOR KEYWORDS
Telepresence interaction, touching live video image, TIUI, telepresence robot, tele-interactive device.

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: User Interfaces.

INTRODUCTION
In a smart world, we can see and talk from anywhere in the world to others located anywhere else on Earth. We can view remote locations live through webcams, and also experience and interact with the remote environment as though we were actually there [45, 24]. So far, a variety of systems and applications of interaction with a remote environment are reported, such as video conferencing[43, 11], teleoperation robots [36, 16], telemonitoring [6, 15], telehealthcare[44, 37], and telepresence robots[31, 21, 47]. Most of these systems follow the conventional scheme of interaction style: a user interface with a keyboard, a mouse, graphical buttons, or a joystick for remote control, and a live video image window as visual feedback. They are often designed for a specific task, and also typically require a highly trained user [31]. As touch screen technologies are emerging, such as pads and smartphones, user interface has evolved to a live video image window with overlapping digital buttons [42, 32, 28], which makes the tele-operation platform compact and ubiquitous. Telepresence systems have overturned the physical limitation of presence, i.e. one person can be present in two places at the same time [20]. Currently, most telepresence systems can move around and perform videoconferencing. But how a telepresence system as the embodiment of a user can do what the user wants to do in a remote environment is still an open problem.

Towards the solution of this problem, we present a telepresence interaction framework and system for a smart environment in which one can interact with real common objects in a remote space just by touching its live videos on

This work was supported in part by the Natural Science Foundation of China (NSFC) under Grant No.61375044 and the Specialized Research Fund for the Doctoral Program of Higher Education of China under Grant No.20121101110035
a pad. Figure 1 illustrates an example task of the system. The system is composed of a telepresence robot and tele-
interactive devices in a remote environment (presence space),
the touching live video image user interface (TIUI) used by
an operator (user) in an operation space, and wireless
network connecting the two spaces. The TIUI is our new user
interface which allows an operator simply uses a pad to
access the system anywhere to not only remotely operate the
telepresence robot but also interact with a tele-interactive
device, just by directly touching its live video image. Our
system can be a perfect embodiment of a user to do most of
daily living tasks just by manipulating the live videos of
environments, such as opening a door, drawing a curtain,
pushing a wheelchair, and other like tasks.

Our system is characterized by three-folds:

(1) Activeness: An operator in an operation space uses the
TIUI to remotely interact with the telepresence robot in a
presence space by touching its live video to actively capture
the live video of anywhere in the presence space;

(2) Feelings of being present: An operator in an operation
space uses the TIUI to remotely interact with objects in a
presence space by touching their live video as if he/she
touches them in the presence, and users in the presence space
also feel that the operator in the operation is being present
with them;

(3) Pervasiveness: An operator uses a pad anywhere to
simply access the system to use the TIUI for telepresence
interaction.

**SYSTEM DESIGN**

Figure 2 show the architecture of the telepresence interaction
system. A tele-interactive device refers to a real object with
its identification, actuators, and wireless communication,
and it is a kind of smart devices. Generally speaking, the
telepresence robot belongs to the family of tele-interactive
deVICES, but it is regarded as our embodiment and excludes
from tele-interactive devices for convenience in this paper.
Having the TIUI, one can efficiently and easily tele-operate

![Figure 2. The system architecture](image)

the telepresence robot and tele-interact with tele-interactive
deVICES just by manipulating their live videos using simple
finger touch gestures.

**Tele-Interactive Devices**

A tele-interactive device has three attributes: identification,
actuation, and wireless communication (such as WiFi
internet). The identification (ID) of a tele-interactive device
should involve its name, location, operation interface,
command, and driver software. A user can directly touch the
live video image of a tele-interactive device via the TIUI to
guide the system to perform recognition of the device. As
long as the device is recognized, it is ready to accept
commands from the TIUI. Figure 3 shows a smart
environment built in our lab with some tele-interactive
deVICES, for evaluating and implementation of our system.

**A Telepresence Robot**

The conventional paradigm for a user to remote control
deVICES in a smart environment is to use a smart phone or a
smart pad with a Graphical User Interface [30, 9]. Most of
live-video-based remote operation systems use a ceiling-
mounted camera to obtain an overhead view of the
workspace and objects as the primary user interface [34]. But
this configuration cannot overcome occlusion problems and
needs more cameras to capture a large view or views of
different areas. Moreover, the users in the remote
environment concern about their privacy disclosed [5, 10].

We propose to use a telepresence robot to be an alternative
solution. Of most importance is that we take advantage of a
telepresence robot as our embodiment being present in the
presence space to perform what we want to do.

Telepresence robots are becoming cheaper and cheaper, e.g.,
Beam, a commercial product from Willow Garage Texai
2015, is less than $2000[47]. There are a variety of
applications ranging from embodied face-to-face meetings
and conversations at offices, to embodied supervising
inspection in enterprises, elderly people care in home, and education at school, and it really will be pervasive in our everyday life.

The advantages of using telepresence robot in our system, in contrast to ceiling cameras, are as follows:

- A user can operate a telepresence robot to go around in the presence space to actively capture the live video there to overcome occlusion problem.
- The robot can friendly present the user’s face, voice, and motion in the presence space, which makes good experiences of both the user and interacted persons.
- The robot follows the design guideline of “If you see me, I see you.” When its screen is black, it means the camera also turns off to elevate concern for privacy.

The F-F Cam is used to capture the live video of the presence space for positioning, tracking, and recognition tasks. The D-F Cam is used to capture the live video of the ground the robot moves on for navigation. The existing systems often use two live video windows respectively from the F-F Cam and D-F Cam as user interface. We found in our testing system that the two windows would introduce some confusion over the presence space, which makes a user to feel missing some views of the presence space, and often change attention between the two windows. Fortunately, the two views from the two cameras in the presence space are overlapping and can be easily stitched as one view for producing one live video streaming and displaying in one window. Figure 5 shows an example of a stitched image for the TIUI.

![Image](image_url)

**Figure 5. Upper Left: the image from the F-F Cam. Lower left: the image from the D-F Cam. Right: stitched image for the TIUI.**

**Touching Live Video Image User Interface (TIUI)**

Rapid developments in smart mobile technology, such as pads and smartphones, have provided important new tools for communication, and changed how we work, learn, spend our leisure time, and interact socially. The TIUI is designed for users to use a pad or smartphone not just to tele-operate the telepresence robot, but tele-interact with tele-interactive devices in the presence space.

The TIUI has three functions as follows:

1. One can use finger-touch gestures to directly touch the live video image of a tele-interactive device on the touch screen to remotely operate it.
2. One can use finger-touch gestures to make markers on the live video image to embed user’s own knowledge into the tele-interaction system.
3. One can be promoted by showing standard gesture actions on the touching region of the live video image to correctly perform tele-interaction.
The first character is the major function of the TIUI we will describe it in detail later. The second character is an enhancing function, which can embed user’s commands (such as grouping and cooperating) as well as user’s knowledge (such as planning and recognition) into the system. A typical example of on-line marking is to draw a moving path and to label obstacles and road edges for navigation. The third character is an additive function. Many touch gestures are emerging, and some of the gestures are so complicated that a mature user is hesitating to act. In this paper, we mainly explore the first character in our system implementation.

**Finger-Touch Gestures**

In our system, we design one-finger gestures for tele-operation of tele-interactive devices and environments, and two-finger gestures to just control the telepresence robot. All gestures are simple and natural and can be easily understood and performed by any user, especially novice users.

**One-finger gesture**

In our daily life, we can use our one-finger to operate almost all the device panel or interface as they are composed of switches, buttons, and sliders. As for a joystick, it can be regarded as a combination of multiple buttons or a track-point of a Think pad computer. Therefore, in our work, we use one-finger gestures to operate most common devices of daily life in the remote environment.

| Robot motion | Forward | Backward | Turn left | Turn right | Left backward | Right backward |
|--------------|---------|----------|-----------|------------|--------------|---------------|
| Two-finger gestures | ![Image](a) | ![Image](b) | ![Image](c) | ![Image](d) | ![Image](e) | ![Image](f) |
| Camera rotation | ![Image](g) | ![Image](h) | ![Image](i) | ![Image](j) | ![Image](k) | ![Image](l) |
| Two-finger gestures | ![Image](m) | ![Image](n) | ![Image](o) | ![Image](p) | ![Image](q) | ![Image](r) |

*Figure 6. One-finger touch gestures for interaction with tele-interactive devices, including (a) tap, (b) lasso, and (c) drag.*

- To interact with tele-interactive devices in the presence space.
- To guide the system to recognize objects and environments.
- To mark motion trajectories or obstacles on the ground for the safety and efficiency of the robot.

Figure 6 shows three types of one-finger gestures used in our system, including tap, lasso, and drag for different interaction task. When a user points any region of a live video image, the system responds the recognition result using CV algorithm or 2D barcode. The user also circulates the region of an object in the image to assist the system to segment the object to be recognized. The user uses a sliding gesture to operate the sliding motion of the object, such as drawing curtain, drawing the volume of voice.

*Figure 7. Two-finger touch gestures for operation of the telepresence robot*
Two-finger gestures

A live video image stitched for the TIUI can be intuitively divided into the upper part and the lower part. Obviously, the upper part from the F-F Cam is concerning about objects to be interacted with, and the lower part from the D-F Cam is about the ground for navigation. Our robot has two distinct parts: body and head. When we use two-finger gestures on the lower part of the live video image (of the robot’s surroundings), the robot is moving according to the gesture meaning. When we use two-finger gestures on the upper video image, the head acts in terms of the gesture meaning. Therefore, we define two modes of two-finger gestures on the upper and lower parts of a live video image in the TIUI. Figure 7 shows two-finger touch gestures for operation of the telepresence robot.

- Two-finger gestures on the upper part of the TIUI are able to control the head of the robot to look around or lift up and down to change the height of the robot.
- Two-finger gestures on the lower part of the TIUI are able to control the robot to move forward and backward, and turn left and right.

The motion action design of two fingers on a touch screen is motivated from the observation of boating and skating strokes. Different modes of strokes corresponds different motion, such as moving forward/backward or turning left/right.

SOFTWARE COMPONENTS OF THE SYSTEM

The software of the system has to address the following issues:

- What does an operator do via the TIUI?
- Who in the live video is being interacted and where it is?
- What in the live video can help the telepresence interaction and where it is?
- How can an operator do interaction with a remote environment and how to do well?

These issues are resolved by the four computing modules: touch, recognition, knowledge, and control. The modules can be performed independently and each module is regarded as a computing state of the system. Theoretically, each state might be transited to any other state, as shown in Figure 8, where the touch module is a start state, visual feedback from the recognition, knowledge, and control actions is carried out by operator’s vision.

Touch Module

In our system, all touch gestures roughly fall into three categories: recognition, knowledge, and control. Touch module aims to perform detection and classification of touch gestures. And according to the result of touch gesture classification, the system state transits to the recognition module, knowledge module, or control module. The operator obtains the visual feedback by looking at the live video of from the telepresence robot in a remote environment and decides to perform next touch gesture for telepresence interaction.

Recognition Module

Recognition is crucial to the system as it builds the correspondence between an object in the live video to the real object for tele-operation of multiple objects in complex environments. The common strategy to recognize an object is to use computer vision (CV) technologies, to learn or extract object features, such as color, texture, shape, and appearance. The simple strategy is to use a 2D bar code or RFID, two of the most popular tools for identification in everyday life. In our system we adopt both strategies, and CV is used first for common object recognition, and the 2D barcode is used if the CV fails or not easy to perform the recognition.

A recognized object is automatically locked on and tracked when the object or robot are moving. If the TIUI loses the tracked object, the user fails to interact with the object and need to start the recognition module once more.

![Figure 8. The computing modules](image)

Figure 8. The computing modules

![Figure 9. Three basic state transition Diagrams of the computing modules. 1-Touch, 2-Recognition, 3-Knowledge, and 4-Control. (a) Traditional tele-operation, (b) Tele-operation with recognition, and (c) Tele-operation with knowledge.](image)

Figure 9. Three basic state transition Diagrams of the computing modules. 1-Touch, 2-Recognition, 3-Knowledge, and 4-Control. (a) Traditional tele-operation, (b) Tele-operation with recognition, and (c) Tele-operation with knowledge.
Knowledge Module

Knowledge module aims to embed human knowledge into the system for enhancing safety and efficiency of tele-interaction. In our system, we make markers on the live video images of a remote environment for embedding knowledge, such as obstacle mark, route mark, door mark, and the like. Similar to recognition module, a marked object is automatically locked on and tracked when the object is moving.

Control Module

Control module is a process of executing the user’s decision from the TIUI to remotely control the tele-interactive devices in the presence space. Control contains a command sequence set which is formed by combining touching gestures, the prior knowledge, and ergonomics. In order to ensure safety and efficacy, the system follows “step action” strategy under human-centered framework. In other words, each step is supervised by an operator. For efficiency and comfort, the control module includes semi-autonomous navigation and obstacle avoidance.

Basic State Transition

Traditional remote control systems generally contain two modules, touch and control, only for tele-operation of one specific device, and it is not flexible to tele-operate other devices. Our system can remotely operate any object since our system contains recognition module. Currently, our system runs in the three basic states and their combination, as shown in Figure 9.

The transition from State 1 to State 4 is a typical traditional one-to-one remote-control strategy (Figure 9a) where the user is watching the live video of an object as visual feedback (dashed blue arrow), and his/her hands operate the physical or graphical buttons or joysticks to control the device. The transition from State 1 to State 2 (Figure 9b) is a distinct feature of our system which makes it to interact with multiple common objects in complex environments. The transition from State 1 to State 3 (Figure 9c) is advanced feature for embedding knowledge to the system.

PRELIMINARY EVALUATION OF THE TIUI

Using a between-participants experiment, we evaluate the TIUI compared with the GUI (graphic buttons). Participants are asked to operate a telepresence robot through an obstacle course twice by using finger touch gestures (The TIUI) and hitting the graphic buttons (GUI), respectively. Immediately after finishing the task, participants complete a questionnaire to evaluate the two user interfaces.

Participants

Ten adult volunteers (five females and five males) from the university population participated in our study. (Ages: 18-28 years, M=23.5, SE=1.8) Each participant was paid $10 per hour for participating the experiment.

Environment

The environment consisted of a path outlined by colorful cups through an office space, and a digital video camera for recording the behavioral performance of each participant.

Procedure

Instructions about how to use the TIUI and the GUI to operate the telepresence robot are provided. Participants are allowed to practice the operating through the obstacle course for as long as they wished.

When the participants are ready for the test, they go to the starting line of the obstacle course and complete one loop of the course by using one of the two user interfaces. The time used for the loop is recorded. After the loop, the participants are asked to complete a questionnaire for evaluation, and go back to the starting line for the other loop.

Measures

Practice Rounds

Before the test, the participants are allowed to practice through the course as many times as they want. The numbers of practice rounds completed by each participant are recorded.

Performance

Performance is evaluated by the time used to finish the course and the number of cups that the participant accidentally pushed.

Experience

![Figure 10. Comparison of the two methods](image_url)

Maneuverability and feeling of presence are gauged in a questionnaire. Participants were asked the following questions: “How do you feel about the maneuverability of the operation?” and “How do you feel about the presence of yourself in the presence space?” Participants then rated their attitudes ranging from 1 (describes very poorly) to 4 (describes very well).
Appearance

The operators’ face images on the tele-presence robot screen were rated to calculate an average score of how well the participant presented herself or himself in terms of the quality of the operator’s on-screen appearance.

Figure 10 shows the comparison results between the two user interfaces.

Analysis

We use an analysis of variance (ANOVA) for testing the effects of the way of operation upon each of the dependent variables of interest (number of practice rounds completed, performance, experience and appearance). To test for relationships between the dependent variables, we used Pearson correlation calculations. For tests of statistical significance, we used a cut-off value of p<.01.

Result

Practice Rounds and Performance

Participants practiced more rounds when using finger touch gestures (M=1.5, SE=0.47) than using graphic buttons (M=1.45, SE=0.34), p=.016. The reason is that it’s the first time for most participants to use gestures to control a robot, while many participants have the experience of using buttons for controlling, such as controlling a car or character in games. Participants can easily control the rotation angle and speed when using finger touch gestures. Therefore, the number of cups that the participant accidentally pushed is much less by using gestures than using buttons, and the time used to finish the course is also shorter.

Experience

Participants experience similar maneuverability (M=3.5, SE=0.85) when using finger touch gestures as using graphic buttons (M=3.45, SE=0.823), p<.01, but have better presence experience, p=.15. The finger touch gestures are like the way of boating or skiing in our daily life, which makes the participants feel much more presence.

Appearance

The coders rated participants as looking better (M=2.2, SE=0.42) when using finger touch gestures than using graphic buttons (M=3.3, SE=0.67), p=.05. When using finger touch gestures, the participants feel just like they are in the presence space. The appearances on their faces indicate that they enjoy the operation.

DEMONSTRATIONS AND DESIRABLE APPLICATIONS

We perform four demonstrations, including tele-operation of the telepresence robot, telepresence interaction with the smart environment, telepresence operation of wheelchair robot, and telepresence domination of swarm robots, to show some potential and desirable applications of our telepresence interaction system.

Tele-Operation of the Telepresence Robot

Telepresence robots can be used in many application areas, such as office environments [40], health care [40], assistive life for elderly [26], and school environments [38]. Our TIUI for a pad allows an operator to perform the tele-operation of the robot to move and look around efficiently and naturally.

Figure 11. Two-finger gestures on the lower part of the TIUI to tele-operate the Mcisbot to move forward and turn around. (a) Reference position, (b) Move forward, and (c) Turn right.

We have designed finger touch gestures shown in Figure 6 and Figure 7. This section demonstrates the execution of the

Figure 12. Two-finger gestures on the upper part of the TIUI to tele-operate the Mcisbot head to look around. (a) Look left. (b) Look forward. (c) Look right.
gesture sets on the upper part and lower part of the live video image, respectively, for tele-operation of our telepresence robot Mcisbot. Figure 11 shows that a user uses the two-finger gesture on the lower part of the TIUI in the operation space to tele-operate the robot to move forward and turn right. Figure 12 shows that the user uses the two-finger gesture on the upper part of the TIUI in the operation space to tele-operate the robot head to look around. Figure 13 shows single-finger gestures on the lower part of the TIUI to mark obstacles and trajectory on the ground for robot navigation.

Figure 14 A user uses the TIUI to remotely open the auto-door with password access control. (a) See the 2D-codebar of the password panel. (b) Point tap the 2D barcode and recognize the password panel. (c) Input password to open the door.

Figure 15. A user uses the TIUI to remotely draw the curtain. (a) One uses one-finger gesture to select a region (blue circle) for the system to recognize. (b) The curtain is activated (blue rectangle). (c) One draws the curtain by using one-finger touch gesture.

Figure 13. Single-finger gestures on the lower part of the TIUI to mark obstacles or trajectory on the ground for robot navigation. (a) Mark a chair on the way of the robot as obstacle (b) and (c) Mark a trajectory of the doorway for the robot.

Telepresence Interaction with the Smart Environment

We build a smart environment in our lab as a presence space with some tele-interactive devices, such as an auto-door with password access control and doorbell panel, a light source control panel, an electric curtain, telepresence robot Mcisbot, and a tele-operation wheelchair, as shown in Figure 3. A user in the operation space can use the TIUI to interact with the tele-interactive devices in the presence space in a “see and operate it” way. Figure 14 shows that a user uses the TIUI to see the auto-door with password access control and doorbell panel, circulate it with one-finger gestures for recognition, and input the password as the user does it in the presence. This demonstration shows the system can tele-operate any switch like button for telepresence interaction in an intuitive and natural way.

Figure 15 shows that a user can easily use the TIUI to remotely draw the curtain. First, a user uses the TIUI to look at the curtain and user one-finger touch gesture on the image of the curtain to guide the system to recognize it, and then follow to a graphic prompt to draw the curtain.
**Telepresence Operation of a Wheelchair**

Our world is facing the problems associated with an increasing elderly population. It was found that activities concerning mobility, self-care, and interpersonal interaction & relationships are most threatening with regard to the independent living of the elderly [1]. In order to maintain the quality of home care, the elderly people needs not just a wheelchair for assisting their ability, but a telepresence robot as the embodiment which allows elderly people at home to communicate with the family members or caregivers. Tsai et al. [40] found that the telepresence robot enabled elderly people to regard the telepresence robot as a representation of the robot operator (family members or caregivers). In our demonstration, we attempt to use our telepresence robot Mcisbot to push the WiFi wheelchair for elderly people as his/her family member to do, as shown in Figure 16. Figure 17 shows a user uses the TIUI to push the wheelchair with one-finger gesture.

**Telepresence Dominating swarm robots.**

Swarm robots are able to work together with other robots to accomplish tasks, such as assembly of an object, and search and rescue operations. We use our Mcisbot to tele-dominate swarm robots in a presence space, such as game fields, battlefronts, and search sites. Figure 18 shows the configuration of swarm robots domination by using our system. Figure 19 shows that a user remotely operate the swarm robots by using the TIUI.

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**Figure 16.** An electric wheelchair for elderly people pushed by a person (a) and by the telepresence robot (b).

**Figure 17.** The user pushes the wheelchair with one-finger gesture via TIUI, and the telepresence robot moves to follow the wheelchair.

**Figure 18.** The configuration of swarm robots dominated by the Telepresence robot Mcisbot with the TIUI.

**Figure 19.** Swarm robots dominated by the Telepresence robot Mcisbot with the TIUI. (a) The Mcisbot and interactive robots, (b) Control one robot to go somewhere by dragging it. (c) Control three robots to go somewhere by dragging them.

**RELATED WORK**

**Live Videos-Based Interaction**

An early attempt to use live videos for interacting with a real object located at a distance stems from Tani et al. [39] in 1992. They presented interactive video techniques to implement a system for monitoring and controlling an electric power plant. Recently, Seifried et al. [34] developed an integrated remote control system CRISTAL which allows
a user to control home media devices through the live video image of home captured by a ceiling camera by using an interactive tabletop system in the same home. Kasahara et al. [17] reported an interaction system eXTouch which enables a user to control the physical motion of a target device by simply touching and dragging through the camera on the screen and also by physically moving the screen in relation to the controlled object. Boring et al. [3, 4] presented a system Touch Projector that enables a user to interact with remote screens through a live video image on their mobile device. The handheld device tracks itself with respect to the surrounding displays. Touch on the video image is “projected” onto the target display in view, as if it had occurred there. Sakamoto et al. [33] presented a video-based Tablet interface to control a vacuum cleaning robot system in which ceiling mounted cameras provide the user a top-down view that enables the user to control robots and design their behaviors by sketching on the camera using a stylus pen. Kato et al. [18] proposed a multi-touch tabletop interface to control multiple robots simultaneously by manipulating a vector field on a top-down view from a ceiling camera. Guo et al. [13] presented user interfaces for remotely interacting with multiple robots using toys on a large tabletop display showing a top-down view of the workspace. Sekimoto et al. [35] proposed a simple driving interface for a mobile robot using a touch panel and first-person view images from the robot. Once the user gives a point of the temporary goal position by touching on the monitor displaying the front view of the robot, the system generates a path to the goal position and the vehicle is controlled to follow the path to reach the goal position autonomously. Correa et al. [8] proposed a handheld tablet interface for operating an autonomous forklift, where users provide high-level directives to the forklift through a combination of spoken utterances and sketched gestures on the robot’s-eye view displayed on the interface. TouchMe [14] is a system for tele-operating a mobile robot through a touch panel. These approaches provide real-time visual feedback and intuitive touch interaction.

So far to our best knowledge, there is no work reported on interacting with multiple common objects appearing in our daily living in a remote environment through live videos, especially by touching live video images of objects on a pad which can make a user to access the system to perform interaction anywhere.

Telepresence robots
There are some commercially-available products, such as VGo [46], Giraff [12], and Beam [47]. Most of existing systems use the mouse, keyboard, or joystick based user interface to tele-operate robots. Some of them use touch screen but only convert physical keyboard or joystick into digital ones on the screen.

There is no work reported on using telepresence robot in a remote location as our embodiment to interact with common objects just by touching live videos as if we do it in the presence.

LIMITATIONS
There are two key limitations in our study. First, the telepresence interaction system is designed for smart environments containing tele-interactive devices. Currently, smart devices can be remotely controlled via wireless communication, which makes the system usability in smart worlds, but most of every day devices are just electric powered, and need to “add on” recognizable WiFi actuators. Second, having recruited a small sample from a university campus, there are limitations to the generalizability of our study.

CONCLUSIONS
We have presented the telepresence interaction framework towards smart world under which one can realize the interaction with common objects in a remote environment just by touching its live video as if his/her ding in the presence. We have proposed a novel User Interface, called TIUI, which allows a user to touch the live video image of a real object from a remote environment on a touch screen. We have developed the telepresence system composed of a telepresence robot and tele-interactive devices in a presence space, the TIUI in an operator space, and wireless communication connecting the two spaces. The preliminary evaluation of user studies and experimental demonstrations show that the proposed framework and methodology are promising and usability.

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