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Best practices on Augmented Reality

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Contents

By Fraunhofer AICOS for:

Project: SINATRA

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Interaction Models

This document reviews each single interaction model that can be used in AR applications.

Interaction Model		Type of input	Description/Use	Similar alternatives	When it is useful	Be careful to
Hands		Gestures	Hands and/or remote controllers enable the user to interact with the AR environment. The user controls holograms and menus using instinctive or acquired gestures.	Tactile	Users need to interact directly with the AR world, in the most immersive way possible.	The constant use of gestures can cause muscle fatigue.
Gaze		Head and eye motion	Actions are committed with a point and click approach. Head or eye gaze can be used, with the former being slower but more reliable for small targets and the latter faster but difficult to use with small targets.	Vocal	When users needs to have their hands free but still be able to interact with the smart glasses.	Low light environment may bring to a poor experience. Using head gaze for a prolonged period can bring to neck muscle fatigue.
Vocal		Voice	Voice is used to select and commit actions. Users just have to say one of the existent voice commands related to a specific action.	Gaze	When users needs to have their hands free and are constantly moving their heads.	May be difficult to use when inside noisy environment.
Camera		Camera input	Frequently used to scan the environment and gather data to be used in creating and positioning holograms in the user's field of view. The camera can also be used to scan AR markers, QR codes and barcodes.	/	When users need to scan external items and input them inside the smart glasses.	Low light environment.
Motion		User movements	Users can interact with holograms by moving (body proximity) and by changing their point of view (body perspective). In both cases, this can trigger actions such as a change in appearance or a change of the hologram's position.	Hands	Using motion is very useful when designing interactive experience for the user.	This mode requires enough space to move in security.
Tactile		Touch	By touching and swiping is possible to select holograms and execute actions. This model is the most similar to 2d interaction.	Hands	When users have difficulties in interacting with holograms directly. This mode can help users that have never used AR and use a smartphone/tablet every day.	The constant use of touch can cause muscle fatigue when used with a raised hand.

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Interaction multi-models

This document reviews each single interaction multimodel that can be used in AR applications to design more flexible experiences.

Interaction Multimodel	Type of inputs	Description/Use	When it is useful	Be careful to
Motion controller + Voice	Motion controller and voice	Holograms and menus can be selected using a motion controller and the action can be committed using the user's voice.	Can help the user during the first approach with AR	Cannot be used when a hands free approach is needed. May be difficult to use when inside noisy environment.
Gaze + Voice	Eye motion and voice	Using eye gaze, users can select objects and commit actions using voice.	This multimodel is the second fastest of all multimodels.	Commit time can be long, this multimodel can be perceived as slow. May be difficult to use when inside noisy environment.
Gaze + Hands	Eye motion and gestures	Users can select objects using eye gaze and commit actions using gestures.	This multimodel is useful when there is the need of selecting object far away from the user in a faster way compared to Hand + Voice.	Using hand gestures can bring to muscle fatigue.
Hands + Voice	Gestures and voice	Hand rays are used to select holograms and menus, action are committed using voice.	Can help in selecting objects that are far from the user, without the need of moving.	Using hand rays can bring to muscle fatigue.
Gaze + Clicker	Eye motion and external clicker	Selections through eye gaze and commit using an external device.	This multimodel is the fastest and easiest to use.	Requires one hand to commit actions.
Gaze + Motion controller	Eye motion and motion controller	Items are selected using eye gaze and action are committed using a motion controller.	With this multimodel, selection is faster that other alternatives and more precise.	Cannot be used when a hands free approach is needed.

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Taxonomy and most common interaction patterns

This document reviews each single interaction multimodel that can be used in AR applications to design more flexible experiences.

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In this document you can find information about each single interaction pattern that can be used in AR applications, its alternatives and combatible devices.

Interaction Model	Interaction Pattern	Common use	Alternative actions that work well with this pattern	Alternative gestures	Compatible Devices
Hands	Rotate	To rotate holograms designed in 3 dimension.	To investigate the shape of a 3D hologram. To change holograms's appearances. To select a visual or interactive state.	Voice Command Air tap	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Move	To move holograms around the mixed environment.	To change an item's position. To select a visual or interactive state. To select an item To give directions	Slider Tap Head gaze and dwell Eye gaze and dwell	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Resize	To change height and width of every hologram.	To change holograms's appearances. To zoom in and out. To select an item.	Voice Command Slider 2D Button Pinch Air tap	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Palm menu	To show different options. Options are fixed to the user's hands.	To show different shortcuts when drawing (colors, styles, thickness). To scroll through instructions. To change holograms's appearances. To select different items. To trigger actions (fireworks, explosions, color filters).	Voice Command	Microsoft HoloLens 2
	Wrist menu	To show only one option. The option is fixed to the user's hands.	To scroll through instructions. To change holograms's appearances. To select one item. To trigger actions (fireworks, explosions, color filters).	Voice command 2-finger tap Bloom Camera recognition Voice Command	Microsoft HoloLens 2
	Near Menu	To show different options. The near menu can be static or dynamic (moves when the user moves)	To scroll through instructions. To change holograms's appearances. To select one item. To trigger actions (fireworks, explosions, color filters).	Voice Command	Microsoft HoloLens 2
	Slider	To set value in a fast way.	To change through visual states (xray, wireframe, solid). To scroll through instructions. To change holograms's appearances. To select different items. To give directions	Hand ray Eye gaze Head gaze Move Rotate Voice Command 2-Fingers Swype	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S
	2D button	To execute an action. Usually requires hands or tactile models.	To change a visual state (xray, wireframe, solid). To scroll through instructions. To change holograms's appearances.	Air Tap Wrist menu Eye gaze and dwell Head gaze and dwell Voice Command	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S
	Virtual Keyboard	To type characters on the screen using the user's hands	To change a visual state (xray, wireframe, solid). To scroll through instructions. To change holograms's appearances.	Voice Command	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S
	Scroll	To scroll through windows and documents.	To scroll through different options To read documents. To change holograms' positions To change a visual state (xray, wireframe, solid).	Eye gaze Head gaze Swipe Move Voice Command	Microsoft HoloLens 2
	Pinch	To zoom in and out.	To investigate the shape of a 3D hologram. To create motion in 3d models	Slider Scroll 2D Button Voice Command	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S
	Air Tap	To commit an action.	To scroll through instructions. To change holograms's appearances. To count the tempo	2D Button Wrist Menu Voice Command	Microsoft HoloLens 2
	Bloom	To go back to a previous menu.	To change holograms's appearances. To trigger actions (fireworks, explosions, color filters).	Wrist Menu 2D Button Voice Command	Microsoft HoloLens 2
	Hand ray	To interact with far objects.	To select holograms. To give directions. To draw. To change holograms's appearances. To trigger actions (fireworks, explosions, color filters).	Voice Command Eye Gaze Head Gaze	Microsoft HoloLens 2
	Obstruct the view	To trigger different changes in state.	To select holograms To change holograms' appearance To show/hid holograms To push hologram away	/	Microsoft HoloLens 2
	Hand Proximity	To trigger different changes in state.	To select holograms To change holograms' appearance To show/hid holograms To push hologram away	/	Microsoft HoloLens 2
Motion	Move body	To explore the mixed reality environment.	To change the mixed reality appearance. To find hidden items.	Move Eye gaze Head gaze Voice Command	Microsoft HoloLens 2
	Tilt body	To explore the mixed reality environment.	To change the mixed reality appearance. To find hidden items.	/	Microsoft HoloLens 2
Gaze	Head gaze	To select holograms using the user's head.	To push hologram away. To scroll through instructions. To rotate objects.	Eye gaze Hand ray	Microsoft HoloLens 2 VUZIX M400 Realwear HMT-1
	Eye gaze	To select holograms using the user's eyes.	To push hologram away. To scroll through instructions. To rotate objects.	Head gaze Hand ray	Microsoft HoloLens 2
	Head Gaze Dwell	To select and commit actions using the user's head.	To change holograms' appearance. To give directions. To move objects. To rotate objects.	Eye gaze and dwell	Microsoft HoloLens 2
	Eye Gaze dwell	To select and commit actions using the user's head.	To change holograms' appearance. To give directions. To move objects. To rotate objects.	Head gaze and dwell	Microsoft HoloLens 2
Voice	Voice Command	To execute actions using the user's voice.	To change holograms' appearance. To let holograms follow you. To change interaction model.	All patterns	Microsoft HoloLens 2 VUZIX M400 Realwear HMT-1
Tactile	Tap	To commit action using one finger.	To scroll through instructions. To change holograms's appearances. To count the tempo	2D Button Air Tap Voice command	VUZIX M400 Epson BT-40S Realwear HMT-1
	Swipe	To scroll through content. To move a selected item.	To give directions. To move objects. To scroll through instructions. To draw	Move Scroll	VUZIX M400 Epson BT-40S Realwear HMT-1
	2-Fingers Swipe	To commit important actions that require a more precise approach.	To Raise the volume. To Lower the volume. To Go back to a previous state. To Set brightness	Slider Short press button Long press button	VUZIX M400
	2-Fingers tap	To commit important action using two fingers.	To toggle AR mode. To close an app. To go back to a previous state. To confirm actions.	Wrist menu Bloom Long press button	VUZIX M400 Epson BT-40S Realwear HMT-1
	3-Fingers tap	To commit very important action using three fingers.	To turn off the screen.	Short press button Long press button	VUZIX M400
	Short press button	To commit actions or interact with holograms using a physical button	To change a visual state (xray, wireframe, solid). To scroll through instructions. To change holograms's appearances.	Air Tap Wrist menu Eye gaze and dwell Head gaze and dwell Voice Command 3-Fingers tap	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Long Press button	To commit important action using one fingers	To toggle AR mode. To close an app. To go back to a previous state. To confirm actions.	Wrist menu Bloom 2 Finger tap 3-Fingers tap	VUZIX M400 Epson BT-40S Realwear HMT-1
Camera	Camera recognition	To commit actions or interact with holograms using a built-in camera input.	To create new holograms. To take pictures. To scan external items	/	Microsoft HoloLens 2 VUZIX M400 Realwear HMT-1

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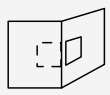
Feedback cues for the final user

This document describes each single visual, auditory, and kinesthetic cue that you can use to help the user when designing feedbacks in AR.

Type of cue	Cue		Description	Can be used to	Compatible Devices
Sound	Color		Using color can help holograms in appearing more natural and also offering guidance and help for the user.	As a visual cue, to help users focus on specific areas of the virtual environment.	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Sound		In mixed reality, sound is mostly used to inform and reinforce mental models of the state of an application. It's a good idea to use sound when there is a lack of tactile feedback.	Can be used to inform users that a change has occured (even if wasn't initiated from the user). Sound will also help reinforce stage transition.	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Cursor		Cursors give an instant and continous positional feedback to the users. Usually, cursors are used with head gaze and hand interaction models but can also be used when using tactile mode.	Tell the users where the headset believes their current focus is at a given time. Understand if an hologram can be interactive or not.	Microsoft HoloLens 2 VUZIX M400
	Bounding Box		A bounding box tells the user that an hologram is interactive and that can be resize.	To inform the user that an object is resizable or can be rotate through direct manipulation or hand rays.	Microsoft HoloLens 2
	Voice Input suggestion		Voice input can be used to get access to all the mixed reality areas.	To hint what command to use for a specific action	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Tooltip		Short description related to an hologram or a specific control.	Can be used to tell users where to look or to describe particular elements of an hologram. Can convey a hint or extra information.	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S
	Slate		A slate is the 3D equivalent of a window inside an operative system.	Can be used to show text or static images.	Microsoft HoloLens 2
	Shader		Shading gives the ability to show holograms with different visual clues.	Conveys visual cues to the user and make holograms more integrated to the real world.	Microsoft HoloLens 2
	Dialog		A piece of UI capable of showing users important information in a 2D representation	Shows important information which can require or not the user intervention.	Microsoft HoloLens 2 VUZIX M400 Epson BT-40S Realwear HMT-1
	Hand coach		A hand coach give the user a hint on how to interact with a UX component.	To show the user what kind of gestures are possible and what interactions are possible. There are several hand coaches, one for each main gestures; more can be designed for a specific purpose.	Microsoft HoloLens 2
Visual	Spatial mesh		Spatial mesh provides a visualization of what an how the device is perceiving the external world.	To show the user what the device can see while providing spatial context.	Microsoft HoloLens 2
	Progress Indicator		The progress indicator can be usually found when the devices is loading assets or executing action in the background	To be used when you want to communicate to the users that something is loading and that they need to wait.	Microsoft HoloLens 2 Realwear HMT-1 VUZIX M400 Epson BT-40S
	Surface Magnetism		Holograms will follow the spatial context, giving the impression that they are real.	May be used when you want to design life-like experiences.	Microsoft HoloLens 2
	Proximity Light		A proximity light communicates the user what object are interactable and how to interact with them.	Useful to give a secondary feedback, included with sounds.	Microsoft HoloLens 2

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This document contains several check-lists of good practices useful when designing for AR applications.

Basic comfort guidelines

HOLOGRAMS

Holograms are positioned within 1,25 to 5 meters from the user

Optical distance should be between 1.25 to 5 meters away from the user. The best distance is usually 2 meters away from the user's eyes. In any case, items should not be presented closer than 40 cm.

USER INTERFACE

Head and neck movement angle is between 0 and 35 degrees

The optimal region should be between 0 to 35 degrees below the horizon.

EYE GAZE

Gaze direction is within limits

When using eye gaze mode, you should take into consideration the eye's angle of vision. Gaze vision should be within 10 degrees above the horizon and 60 degrees below the horizon

USER INTERFACE

Neck Rotation is within limits

The neck's rotation angle should be no more than 45 degrees from the center of the horizon

HOLOGRAMS

Virtual objects are easily reachable

All objects that should be interacted using fingers and hands, should be comfortably in reach for all users. Therefore, objects should be positioned at around 50 cm.

GESTURES

Use of gestures in mid-air is under control

If hand gestures are needed, it is better to avoid constant and repetitive gestures input. Action such as Air tap, during long maintenance sessions, can bring muscle fatigue.

EYE GAZE

All text is legible

According to the Microsoft's guidelines, to be legible in mixed reality, a text should be 9 and 12 pt high when 45 cm apart from the user's vision and within 35 and 39 pt high when is located at 2 meters from the user.

EYE GAZE

Thin text font has not been used

Due to the way smart glasses works, thin strokes are not rendered very well. A font too thin can end up in giving a visual sensation of vibration and will affect legibility.

Legibility guidelines

USER INTERFACE

UI implements dark colors

When designing a UI, it is always better to use dark colors to prevent eye fatigue and grant legibility. To give the appearance of a black color you can set RGB 16,16,16.

USER INTERFACE

Bright backgrounds are not used

Bright backgrounds can be eye fatiguing for the users. If a bright color is needed, it is alway better to design a transparent UI backplate.

USER INTERFACE

Backgrounds are not completely occluding the user's hands

When backgrounds are designed with solid colors, the user's hands are not always visible, making difficult to perceive the depth/distance between the hand/finger to the target surface.

ENHANCE VISIBILITY

Vignetting has been implemented

By using a vignetting effect, it is possible to enhance the user's visibility, as the darker borders helps him/her focusing on the screen's center.

ENHANCE VISIBILITY

UI is adapts to the external environment

Some variations in ambient lighting can affect the usability of an application. A black background might be unreadable when outside of a building due to screen glare, while a page with a white background might be difficult to look at when the user is in a dark room.

ENHANCE VISIBILITY

UI background is solid

To increase legibility even further, it is possible to use a solid UI background. This will help with legibility but can increase the difficulty in perceiving the hand's position, so this should be use with care.

Good Design guidelines

GESTURES	All the possible gestures have been explained *When onboarding the user, it is always useful to explain what gestures can be used within the application.*
HOLOGRAMS	Holograms are created within the user's field of view *When designing interaction and experience in AR it is always better to draw holograms that are within the user's field of view. In case this was not possible, tendrils that lead to that hologram should be designed to help the user reaching that item.*
AR SPACE	Environment area has been tested *The environment in which the user lies should be considered. Small spaces may obstruct the user in using gestures.*
USER INTERACTION	Popups have being replaced with thought bubbles *To get the user attention instead of showing a popup in front of the user's field of view, draw a thought bubble with tendrils that user can follow to where their attention is needed.*
USER INTERFACE	Menus complies with usability guidelines *In AR, menus can be static or dynamic (able to follow the user's position) so different approach should be used. If a menu that follows the user is used, it should be the least unobtrusive as possible. If a static menu is chosen, to avoid that the user gets lost it is always useful to draw an arrow that guides the user to the static menu.*
USER INTERACTION	Interacting with holograms gives a feedback *You always should give feedback when interacting within the digital environment (e.g., when triggering an action or when moving an object) .*
USER INTERACTION	Several different feedbacks are given *Due to lack of a tactile interface it is always better to add sounds to reinforce interactions.*
GESTURES	The proximity of a hand triggers a feedback *When the hand is detected in the trackable area there should be a button/slider/selector change in appearance.*
HEAD/EYE GAZE	Targets are outlined when selected *Always outline what the user is interacting with.*
HEAD GAZE	Cursor direction has been highlighted *Draw a shadow to signal the direction in which the cursor is heading.*
HEAD GAZE	Cursor is visible *To help the user in understanding where the head gaze is pointing, a cursor should be made visible*
EYE GAZE	Absence of cursor *When using eye gaze mode, drawing a cursor can be distracting and in the long period can bring to eye fatigue.*
HEAD/EYE GAZE	The "Midas touch" effect has been avoided *It is always best to start a confirmation timer or use voice when a user dwells to a button to avoid confirming unwanted actions.*

USER INTERACTION	User can understand depth when using hand gestures *Users tend to have issues in understanding the AR depth when interacting with the smart glasses. By telling the user if he/she is too far to interact with the UI, this issue can be avoided.*
USER INTERACTION	Users understand how to interact using different modalities *At first, explain briefly how to interact using different interaction models.*
USER INTERFACE	Users know how much environment space is needed to use an app *Always remind the user how much space is needed to interact with an application, to avoid rendering or interaction issues.*
USER INTERACTION	Users can overcome space related issues *If there is not enough space to show the UI, tell this to the users and help them overcome this issue by suggesting different solutions.*
USABILITY	If not needed, hand rays have been removed *Hand rays tend to be distracting for the users. Usually is better to remove them if they are not needed.*
USABILITY	Users know where to find help *It is always helpful to directly tell the user where help in usign the application can be found.*
USABILITY	Visibility of system status *Users should always be able to understand what is happening when they are interacting within AR.*
USABILITY	Recovering from mistakes *User can recover from basic errors with simple gestures.*
IMPROVE USABILITY	Mixed interaction models are used to help flexibility *By combinining different interaction models can help achieve more flexibility, taking the best parts from each interaction model.*

Remote assistance guidelines

USER INTERACTION	A hands-free model can be used *It appeared from the User research documentation that during maintenance sessions, a worker needs to use their hands, a hands-free approach may be helpful.*
USER INTERACTION	Users understand that they are sharing their view *When inside a remote assistance call, users should be able to understand if the connection is active and if they are sharing their view with the remote expert.*
HOLOGRAMS	Low/high light environments have been taken into account *Low light and bright environments seem to not work very well with the HoloLens. A rule of thumb is to use the HoloLens when the human eye can see without efforts.*
USABILITY	Users know if the environment is too bright or too dark *If the environment light is too high or too low to use the application, let the user know that.*
HOLOGRAMS	Hologram's position during maintenance activities are within limits *The holograms should be positioned at the optimal resting gaze angle, which is considered between 10-20 degrees below horizon when doing any activity.*
USER INTERACTION	Technicians can see who they are talking to *Always give the possibility to maintain direct eye contact with the expert and simultaneously show what the technician is seeing.*
USER INTERFACE	Annotations and instructions remain visible *Written instruction or annotations should be always visible and at the same time should not clutter the vision field.*
USER INTERACTION	Annotations can be drawn only by the remote expert *To avoid unwanted actions, annotation should be drawn only by the remote expert.*
USER INTERFACE	An option to clear the user's vision field is available *A way to clear out the field from annotation should be given to clean the user's field of view*
USER INTERFACE	Annotations and instructions position is kept while moving *To avoid the annotation's position getting lost when the user is moving annotations and instructions should be locked to a target.*
USER INTERFACE	Optional interaction models can be set from the app's settings *A worker should have access to at least two different hands-free interaction models. In maintenance tasks head/eye gaze and voice seems to be the most useful.*
USER INTERFACE	Tools for each task have been highlighted *When explaining a specific task, the proper tool to be used should be highlighted.*
USER INTERFACE	Instructions on how to use each tool have been explained *By explaining how to use each tool for a specific task, user can understand better a given instruction. (E.g. Show how to use a tool and how much rotation is needed to execute a task)*
USER INTERFACE	Area designed to leave tools are used *During maintenance tasks, user can understand where to leave tools and where they can retrieve a specific tool.*

Onboarding guidelines

USER INTERACTION

Onboarding starts from the basics
At first, users seems to prefer interacting by scrolling and tapping the holograms using their hands, since that is one of the mental models they have right now because of touchscreens. Therefore, the onboarding process should introduce the user to these simple interactions.

USER INTERFACE

Unnecessary UI is hidden
During the onboarding process it is always better to hide unnecessary UIs to prevent the user from being distracted by something that cannot be interacted with. Instead, always show the UI that the user must interact with to proceed with the onboarding process.

USER INTERACTION

AR interactions are introduced gradually
New ways of interacting in augmented reality should be introduced one at a time, given the fact that people are not used to this technology yet. At first, it is better to show the users how to do a simple action and wait for them to complete it.

GESTURES

If required, introduce pinch gesture early
The pinch gesture is one of the main ways to interact within AR. By pinching you can grasp, manipulate, scale and position holograms so it is important to introduce this gesture early.

GESTURES

Pinch gesture has been explained using a simple example
Pinch gesture can be introduced by asking to the user to mimic the movement on the hand shown on the smart glasses' screen and showing what their action has caused.

USER INTERACTION

Make the user move inside the environment
To teach the user when it is time to show the environment, design a banner that tells them to move their head and show the environment.

USER INTERFACE

Users can always restart the onboarding process
Even if an application has only a couple of functionalities that the user has to learn, in AR it is always better to give the possibility to restart the onboarding process.

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Onboarding example and related guidelines

This document contains an onboarding example and the related guidelines that have been used.

1. Ask the user to place a hand in front of the HoloLens and to keep doing this until the whole hand is covered in mesh.
   Onboarding guidelines : Onboarding starts from the basics

2. If the user is too far to interact with the hands, tell him/her.
   Good design guidelines : Users can overcome space related issues

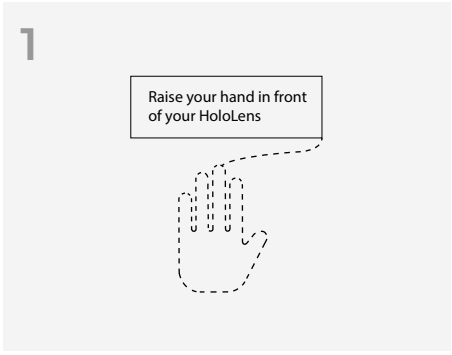
3. Ask user which interaction prefers to use between hands or head/eye.
   Remote assistance guidelines : A hands-free model can be used

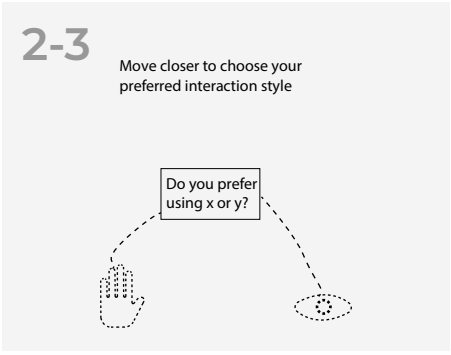
4. Make the main near menu appear with a popup with tendrils that explain what each button means.
   Good design guidelines: Popups have being replaced with thought bubbles

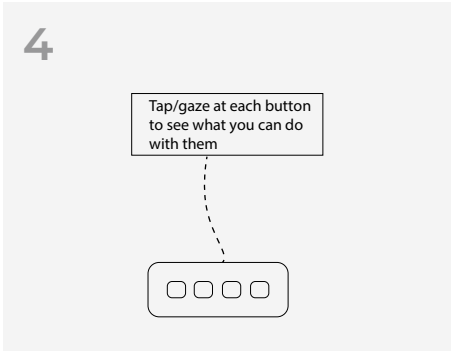
5. Ask the users to push/dwell each button and give feedback when they do it (e.g., the popup disappears).
   Onboarding guidelines : AR interactions are introduced gradually and Interacting with holograms gives a feedback

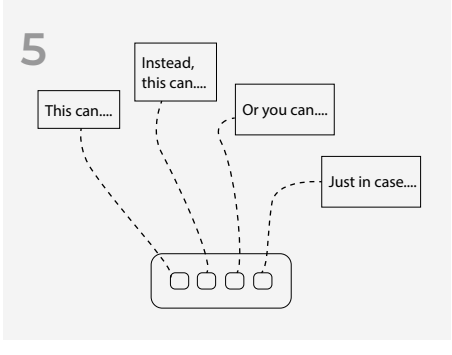
6. After all buttons have been tapped, a new hologram will appear asking the user to login.

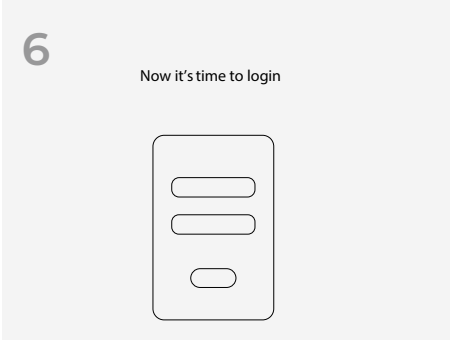
7. After login, show the near menu with the 4 options: join session, QR Code, logout, help (if the user presses help, the 4th step will be executed again).
   Onboarding guidelines : Users can always restart the onboarding process

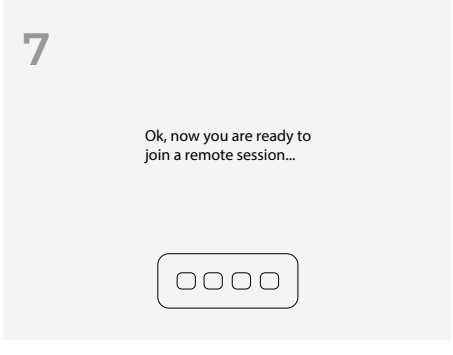










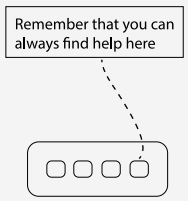


8 Remember the user where help can be found
Onboarding guidelines : Users can always restart the onboarding process

9 Guide the user during the join session process, while giving the possibility to recover from mistakes
Good design guidelines : Recovering from mistakes

10 After joining the remote session, tell the users to move around the space and reminding that they are sharing their view.
Good design guidelines : Visibility of system status
Onboarding guidelines: Make the user move inside the environment

8



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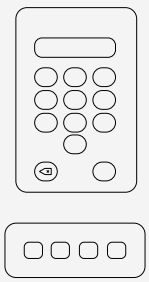

10

By Fraunhofer AICOS for:

Project: SINATRA

Co-funded by: COMPETE 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

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Suggested Interaction Design Pattern

This is a list of suggested interaction design patterns that would be useful to implement in Maintenance remote sessions applications.

Manual Task	Problem	Suggested Interaction Design pattern	Pattern Description	Already in use
Login	Login on smart glasses is slow and diffcult to operate. A virtual keyboard is usually given to type the user's credential, however, this action is often slow and requires a hand interaction model.	Fast join session	Dwelling at a sent QR code through a tablet/smartphone will fill in the login field automatically.	Yes
App homepage	After the login, unless the user already know how to navigate through menus, there are no hints.	Provide a startup guide	After the user will open the app for the first time, a small startup guide will shows up, explaining in simple step how to use the app.	No
	Knowing how to use a palm menu is not always straightforward, also, it requires using two hands, which is not always possible to do.	Follow-me Menu	At startup, provides a small menu that follows the user instead of relying on the palm menu, as it can be confusing for the user at first (such as Microsoft menu).	No
	Sometimes can happen that a menu is left behind. If a menu is not visible it is going to render the interaction with the system impossible.	Location arrow	Provide an arrow that guides the user to where the menu is.	No
Showing the environment	Areas to be maintained are not always easy to find.	Area highlight	When the user looks at the area to be maintained, the system highlights it with some visual cues.	No
	During a maintenance task, parts to be maintained are not easy to distinguish at first.	Location of single parts	While showing the environment to the remote expert, the system highlight the single part to be maintained	No
Understanding Instructions	The remote expert could use gestures to explain a maintenance procedure.	Remote expert miniature	It shows a representation of the remote expert to improve the understanding process of the given tasks.	No
	Tasks can be inverted and executed in the wrong order.	Tasks graphical summary	A list of of tasks to be done are shown divided into steps.	No
	Tasks can be misleading or can be misunderstood	Part and instruction	This pattern highlights each single part with a different color, and connect it with the related number to identify the correct instruction	No
	Written description are not always accurate	Show snapshot and images	When the user will need to see the current state of a part or to understand better an instruction, snapshot and images can be looked at.	Yes
Grab Tools	New tools, at first, are not always easy to distinguish.	Highlight tools that should be used	By dwelling at the maintance tools, the correct tool to execute the current instruction will be highlighted	No
Task execution	/	Show first step	The first task will be highlighted and described	No
	Instructions can be misleading.	Show annotations from the remote experts	A remote expert can draw on the user's screen to highlight a particular item or procedure.	Yes
	/	Scroll through next instructions	After the completion of a task, it is possible to scroll through the next one	No
Showing task results	Maintained areas are not always easy to see.	Highlight maintained areas	After the fulfillement of the task, the mainteined area will be highlighted in a specific color.	No
Leave tools	Often tools can be dangerous or can be missing.	Highlight suggested area to leave tools	When a tool has to be dropped, the system will highlight the area in which drop that specific tool.	No
Exit	Important action should not be executed by mistake	Double confirmation	Before committing an important action, the system will ask the user for a confirmation.	No

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Sources and Literature

This is a list of all the sources read for the creation and organization of this toolkit.

Toolkit Literature

Baltzer, M. C. A., Lassen, C., López, D., & Flemisch, F. (2018). Behaviour Adaptation Using Interaction Patterns with Augmented Reality Elements. In D. D. Schmorrow & C. M. Fidopiastis (Eds.), Augmented Cognition: Intelligent Technologies (Vol. 10915, pp. 9–23). Springer International Publishing. https://doi.org/10.1007/978-3-319-91470-1_2

Battistoni, P., Di Gregorio, M., Romano, M., Sebillo, M., Vitiello, G., & Brancaccio, A. (2022). Interaction Design Patterns for Augmented Reality Fitting Rooms. Sensors, 22(3), 982. https://doi.org/10.3390/s22030982

del Amo, I. F., Galeotti, E., Palmarini, R., Dini, G., Erkoyuncu, J., & Roy, R. (2018). An innovative user-centred support tool for Augmented Reality maintenance systems design: A preliminary study. Procedia CIRP, 70, 362–367. https://doi.org/10.1016/j.procir.2018.02.020

Derby, J. L., Rickel, E. A., Harris, K. J., Lovell, J. A., & Chaparro, B. S. (2020). "We Didn't Catch That!" Using Voice Text Input on a Mixed Reality Headset in Noisy Environments. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 64(1), 2102–2106. https://doi.org/10.1177/1071181320641509

Jeffri, N. F. S., & Rambli, D. R. A. (2020). Guidelines for the Interface Design of AR Systems for Manual Assembly. Proceedings of the 2020 4th International Conference on Virtual and Augmented Reality Simulations, 70–77. https://doi.org/10.1145/3385378.3385389

Ko, S. M., Chang, W. S., & Ji, Y. G. (2013). Usability Principles for Augmented Reality Applications in a Smartphone Environment. International Journal of Human-Computer Interaction, 29(8), 501–515. https://doi.org/10.1080/10447318.2012.722466

Krauß, V., Boden, A., Oppermann, L., & Reiners, R. (2021). Current Practices, Challenges, and Design Implications for Collaborative AR/VR Application Development. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–15. https://doi.org/10.1145/3411764.3445335

Lee, L.-H., & Hui, P. (2018). Interaction Methods for Smart Glasses: A Survey. IEEE Access, 6, 28712–28732. https://doi.org/10.1109/ACCESS.2018.2831081
Palmarini, R., Erkoyuncu, J. A., Roy, R., & Torabmostaedi, H. (2018). A systematic review of augmented reality applications in maintenance. Robotics and Computer-Integrated Manufacturing, 49, 215–228. https://doi.org/10.1016/j.rcim.2017.06.002

Piumsomboon, T., Clark, A., Billinghurst, M., & Cockburn, A. (2013). User-Defined Gestures for Augmented Reality. In P. Kotzé, G. Marsden, G. Lindgaard, J. Wesson, & M. Winckler (Eds.), Human-Computer Interaction – INTERACT 2013 (Vol. 8118, pp. 282–299). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-40480-1_18

Plopski, A., Hirzle, T., Norouzi, N., Qian, L., Bruder, G., & Langlotz, T. (2023). The Eye in Extended Reality: A Survey on Gaze Interaction and Eye Tracking in Head-worn Extended Reality. ACM Computing Surveys, 55(3), 1–39. https://doi.org/10.1145/3491207

Scurati, G. W., Gattullo, M., Fiorentino, M., Ferrise, F., Bordegoni, M., & Uva, A. E. (2018). Converting maintenance actions into standard symbols for Augmented Reality applications in Industry 4.0. Computers in Industry, 98, 68–79. https://doi.org/10.1016/j.compind.2018.02.001

AR general Literature

Ganapathy, S. (2013). Design Guidelines for Mobile Augmented Reality: User Experience. In W. Huang, L. Alem, & M. A. Livingston (Eds.), Human Factors in Augmented Reality Environments (pp. 165–180). Springer New York. https://doi.org/10.1007/978-1-4614-4205-9_7

Güldenpfennig, F., Nunes, F., Subasi, Ö., & Urbanek, M. (2017, July 1). UbiKit: Learning to Prototype for Tangible and Ubiquitous Computing. Proceedings of the 31st International BCS Human Computer Interaction Conference (HCI 2017). https://doi.org/10.14236/ewic/HCI2017.60

Kapp, S., Barz, M., Mukhametov, S., Sonntag, D., & Kuhn, J. (2021). ARETT: Augmented Reality Eye Tracking Toolkit for Head Mounted Displays. Sensors, 21(6), 2234. https://doi.org/10.3390/s21062234

Liarokapis, F., White, M., & Lister, P. (2004). Augmented reality interface toolkit. Proceedings. Eighth International Conference on Information Visualisation, 2004. IV 2004., 761–767. https://doi.org/10.1109/IV.2004.1320227

MacIntyre, B., Gandy, M., Bolter, J., Dow, S., & Hannigan, B. (2003). DART: The Designer's Augmented Reality Toolkit. The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings., 329–330. https://doi.org/10.1109/ISMAR.2003.1240744

Nebeling, M., & Speicher, M. (2018). The Trouble with Augmented Reality/Virtual Reality Authoring Tools. 2018 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), 333–337. https://doi.org/10.1109/ISMAR-Adjunct.2018.00098

Pathmanathan, N., Becher, M., Rodrigues, N., Reina, G., Ertl, T., Weiskopf, D., & Sedlmair, M. (2020). Eye vs. Head: Comparing Gaze Methods for Interaction in Augmented Reality. ACM Symposium on Eye Tracking Research and Applications, 1–5. https://doi.org/10.1145/3379156.3391829

Rolim, C., Schmalstieg, D., Kalkofen, D., & Teichrieb, V. (2015). [POSTER] Design Guidelines for Generating Augmented Reality Instructions. 2015 IEEE International Symposium on Mixed and Augmented Reality, 120–123. https://doi.org/10.1109/ISMAR.2015.36

Vorraber, W., Gasser, J., Webb, H., Neubacher, D., & Url, P. (2020). Assessing augmented reality in production: Remote-assisted maintenance with HoloLens. Procedia CIRP, 88, 139–144. https://doi.org/10.1016/j.procir.2020.05.025

Limerick, Hannah. 'Call to Interact: Communicating Interactivity and Affordances for Contactless Gesture Controlled Public Displays'. Proceedings of the 9TH ACM International Symposium on Pervasive Displays, ACM, 2020, pp. 63–70. DOI.org (Crossref), https://doi.org/10.1145/3393712.3395338.

Best practices websites

'AR Apps: Best Practices and Testing Insights | Userlutions Blog'. Userlutions, 18 May 2021, https://userlutions.com/en/blog/usability-insights-en/best-practices-ar-apps/.

'Augmented Reality'. Apple Developer, https://developer.apple.com/augmented-reality/. Accessed 23 May 2022.

Augmented Reality - System Capabilities - IOS - Human Interface Guidelines - Apple Developer. https://developer.apple.com/design/human-interface-guidelines/ios/system-capabilities/augmented-reality/. Accessed 23 May 2022.

'AR Apps: Best Practices and Testing Insights | Userlutions Blog'. Userlutions, 18 May 2021, https://userlutions.com/en/blog/usability-insights-en/best-practices-ar-apps/.

'Augmented Reality'. Apple Developer, https://developer.apple.com/augmented-reality/. Accessed 23 May 2022.

Augmented Reality - System Capabilities - IOS - Human Interface Guidelines - Apple Developer. https://developer.apple.com/design/human-interface-guidelines/ios/system-capabilities/augmented-reality/. Accessed 23 May 2022.

Development & Interaction Design: XR Bootcamp Lecture - Ultraleap Documentation. https://docs.ultraleap.com/ultralab/development-and-interaction-design.html. Accessed 23 May 2022.

erickjpaul. Comfort - Mixed Reality. https://docs.microsoft.com/en-us/windows/mixed-reality/design/comfort. Accessed 23 May 2022.

'Overview of ARCore and Supported Development Environments'. Google Developers, https://developers.google.com/ar/develop. Accessed 23 May 2022.

Passi, Ankit. 'UX Insights for AR Apps'. Medium, 7 Jan. 2021, https://uxplanet.org/ux-insights-for-ar-apps-5e5b25828c9d.
'Safety and Comfort | ARCore'. Google Developers, https://developers.google.com/ar/design/user/safety-comfort. Accessed 23 May 2022.

Sean-Kerawala. Head-Gaze and Dwell - Mixed Reality. https://docs.microsoft.com/en-us/windows/mixed-reality/design/gaze-and-dwell-head. Accessed 23 May 2022.

Instinctual Interactions - Mixed Reality. https://docs.microsoft.com/en-us/windows/mixed-reality/design/interaction-fundamentals. Accessed 23 May 2022.

'UX Design Principles for Augmented Reality | Adobe XD Ideas'. Ideas, https://xd.adobe.com/ideas/principles/emerging-technology/ux-design-principles-for-augmented-reality/. Accessed 23 May 2022.

Product. https://www.mikealger.com/. Accessed 23 May 2022.

Interaction patterns websites

'Air Tap Button Selection'. Threesixty Reality, 5 July 2019, http://s824284416.websitehome.co.uk/blog/interaction-patterns/airtap/.

Marinho, Fabiano. 'UX Patterns for Augmented Reality'. Medium, 1 Mar. 2021, https://bootcamp.uxdesign.cc/ux-patterns-for-augmented-reality-feac10b35134.

'Patterns for AR'. PRELOADED, https://preloaded.com/ar-patterns/. Accessed 23 May 2022.

Anselm Hook. 'Laundry List of UX Patterns in VR/AR'. Medium, 11 Apr. 2019, https://arvrjourney.com/laundry-list-of-ux-patterns-in-vr-ar-24dae1e56c0a.

WU, Shengzhi. 'AR Interaction Design Toolkit'. Medium, 4 Dec. 2018, https://blog.prototypr.io/ar-interaction-design-toolkit-f47ca0733e31.

XR Design Guidelines - Ultraleap Documentation. https://docs.ultraleap.com/xr-guidelines/. Accessed 23 May 2022.

Sean-Kerawala. Instinctual Interactions - Mixed Reality. https://docs.microsoft.com/en-us/windows/mixed-reality/design/interaction-fundamentals. Accessed 23 May 2022.

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