IMG Work Plan - what's next?

2021-12 – Virtual cam2cam meeting

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Now what?

1. Work on task-based and/or interactive use cases
   - As per original work plan
   - Explore new use cases
     - E.g. immersive collaboration
     - (COVID-19!)

Task based / interactive use cases (summary from original work plan)

Use case		Free navigation	Semantic navigation	Task-based evaluation possible	Interactivity
Uni-directional	Entertainment	✓	+/-	X	X
	Training	✓	✓	✓	X
Bidirectional	Machinery control	✓	v	✓	restricted (well-defined task)
	Human communication	✓	✓	✓	complex (free conversation)

“Within the next two or three years, I predict most virtual meetings will move from 2D camera image grids to the metaverse, a 3D space with digital avatars.“

https://www.gatesnotes.com/About-Bill-Gates/Year-in-Review-2021

Task based / interactive use cases
The problem

- Imagine you have a bi-directional immersive communication system
  - How do you test it?
    - Evaluate effect of technical factors in QoE (e.g. variations of latency / bitrate / etc.)
    - Compare with other systems / experiments
- ITU-T P-920 - Interactive test methods for audiovisual communications
  - Some tasks proposed to evaluate effect of technical factors:
    - E.g.: one of the subjects shows and describes a plastic building block and the other one is required to reproduce it;
  - Centered on video-conference (05/2000)
- ITU-T P.QXM - QoE Assessment of eXtended Reality (XR) Meetings
  - Best practices for QoE assessment of telemeetings with extended reality elements
  - Work in progress (some VQEG members are contributors)

Task based / interactive use cases
Proposal of joint experiment

- Gather a set of **immersive communication systems**, e.g.
  - Real-time 360 video telepresence
  - Social VR with pointcloud transmission / with avatars
  - AR collaboration
- Create an experiment with covers all basic functionalities
  - Conversation between people
  - Discussion about objects in the immersive space
  - Interaction with (local / remote / virtual) objects in the immersive space
- Run a cross-lab experiment using any available collaboration technology
  - “The same” experiment in completely different setups

Target: Creating the “lego-block” experiment for VR/AR/XR

How does the metaverse look like?

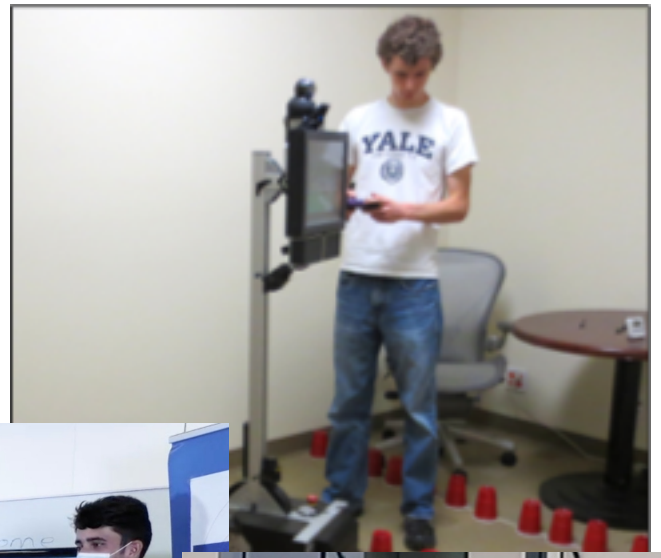
Meta

Microsoft Mesh

CGI avatars immersed on a VR environment / projected on the local environment through AR

How does the metaverse look like?

Pointcloud
video avatars

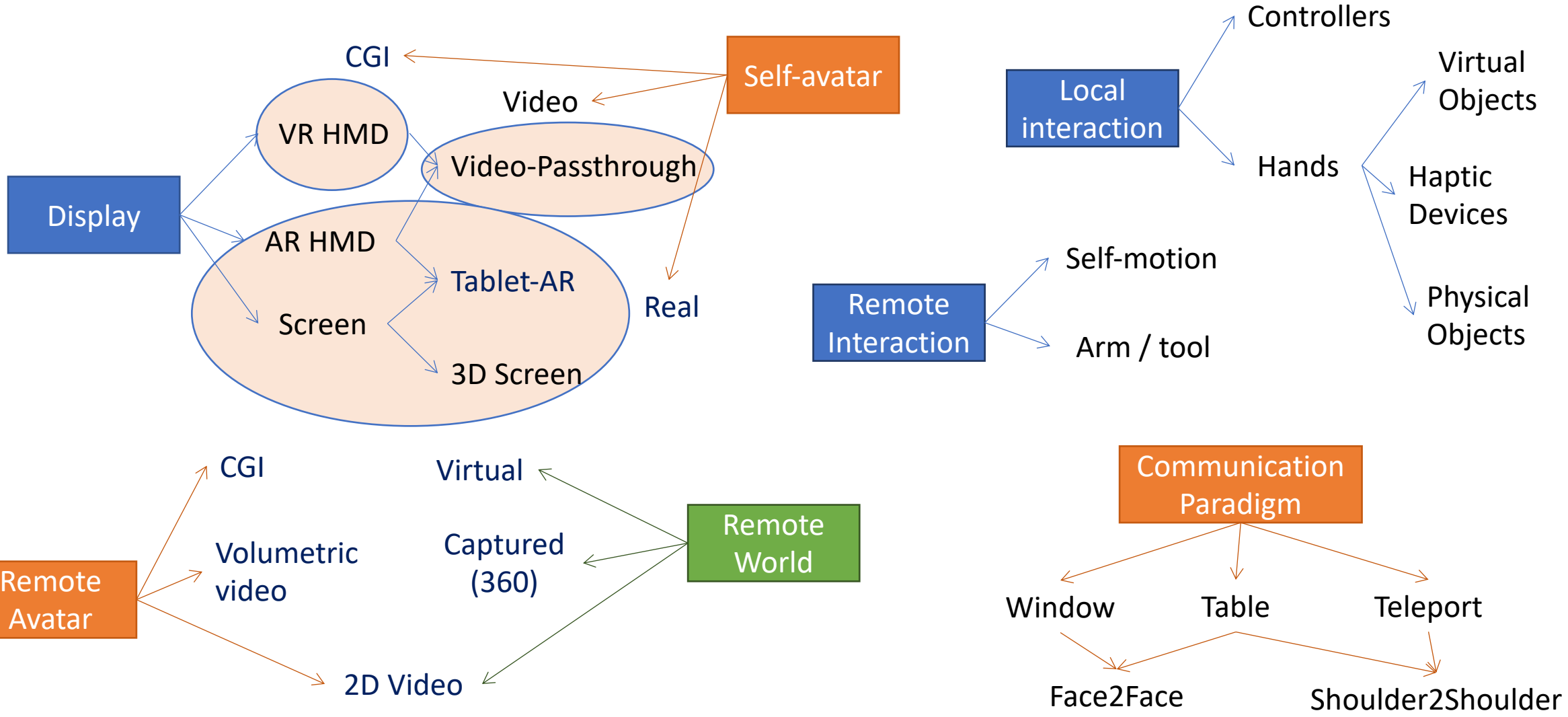


Telepresence
robots

Immersive (e.g. 360) video transmission

Teleoperation of
vehicles / machinery

A taxonomy of immersive systems



Some examples

System	Comm. Paradigm	Display	Self Avatar	Remote Avatar	Remote World	Local Interaction	Remote Interaction
Meta	Table	VR HMD	CGI	CGI	CGI	Virtual Hands	N/A
MS Mesh	Table	AR HMD	Real	CGI	CGI/None	Virtual Hands	N/A
Google Starlite	Window	3D Screen	Real	Pointcloud	Pointcloud	N/A	N/A
CWI SocialVR	Table	VR HMD	Pointcloud	Pointcloud	CGI	Controllers	N/A
Nokia Owl	Teleport	VR(+) HMD	Passthru	N/A - CGI	180/360	Controllers	N/A
UPM FVV Live	Window	Screen	Real	N/A	FVV	N/A	N/A
RISE	Teleport	VR HMD	CGI	N/A	360	Controllers	Crane

Common features and basic tests

- Video + audio
- Two+ people in several locations
  - *Communication* problem
- Limited BW, delay & CPU/GPU
  - (Audio)visual quality
  - Latency / responsiveness
  - Location/pose precision
- Target properties
  - Place presence → being elsewhere
  - Social presence → being with others
  - Closer to real-life experience

1. Conversation
   - Human conversation (flow, empathy…) is supposed to be better
2. Discussion about an object
   - E.g. build a lego block
   - Conversation + visuals
3. Exploration of the environment
   - Immersion in a common location
   - May involve walking / 6 DoF
4. Object manipulation
   - Basic dexterity task
   - Virtual, local or remote (robotic arm)

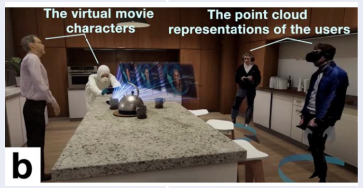
Applying tests to systems

System	Conversation	Object Discussion	Exploration	Object Manipulation
Meta	OK	Virtual	Virtual	Virtual?
MS Mesh	OK	Virtual	?	Virtual?
Google Starlite	OK	Real	?	?
CWI SocialVR	OK	Virtual/Real	Virtual	Local
Nokia Owl	OK	Real	Real	Local
UPM FVV Live	OK	Real	?	?
RISE	?	Real	Real	Remote

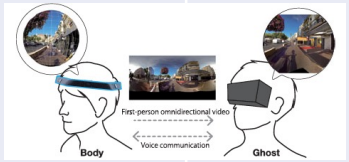
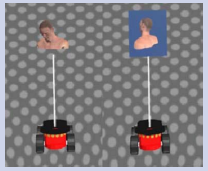
The basic questions

- Which is the minimum number of tasks which
  - allow us to test all the basic features, and
  - apply to as many systems as possible?
- How (if anyhow) are those tasks affected by technical limitations?
- Which are the low level QoE features that we can measure?
  - Task performance
  - Visual quality, responsiveness, etc.
- Which are the high level QoE features that we can measure?
  - Place/social presence
  - Are standard metrics possible (i.e. applying to all scenarios)
- How can we measure?
  - Questionnaires (subjective), behavioural metrics (e.g., gaze/head movements), physiological measures (e.g., EEG, EDA, ECG), and performance measures (e.g., time logging, success rates, etc.).

Overview of (some) user tests

Paper	Task	Display	Self Avatar	Remote Avatar	Remote World	Technical factors	What is measured?	How it is measured?
Brunnström et al. [2020] 	Crane control (log-loading)	VR HMD	CGI	N/A	360	Latency	• VR experience • SSQ • System performance: - Picture quality - System responsiveness - Ability to accomplish the task - Comfort - Immersion - Overall experience	Questionnaires: • Scales 1-5
Li et al. [2021] 	Social VR Movie	VR HMD & Screen	Pointcloud	Pointcloud /CGI	CGI	HMD vs Screen	• SSQ • Quality of interaction • Social connectedness • Presence • Workload • Visual quality (volumetric representations)	Questionnaires: • Social VR questionnaire • Presence questionnaire • NASA Task Load Index • Visual quality questionnaire
Pérez et al. [2021] 	Escape room game	VR HMD	Passthru	N/A	CGI	Passthru vs. controllers	• Presence • Embodiment • QoE	• Questionnaires: • Witmer and Singer's PQ version 3 • Gonzalez and Peck EQ, Perez et al. DREQ

Overview of (some) user tests

Paper	Task	Display	Self Avatar	Remote Avatar	Remote World	Technical factors	What is measured?	How it is measured?
Pan and Seed [2017] 	Play games (competitive and ollaborative)	HMD	CGI	CGI	CGI	Embodiment types: • no self-avatar • self-avatar • face to face	• Task performance • Trust (collaboration)	• Completion time • Questionnaires: - Specific Interpersonal Trust Scale. - Post interview & observations (workspace, communication, body orientation…).
Kasahara et al. [2017] 	Following instructions	HMD	No	No	360	• Video stabilization	• Cybersickness • Exploration behavior • Mediation, roles,…	• Questionnaires • Head movements
Zhang et al. [2019] 	Indicate remote user's gaze	HMD	No	CGI	360	• Distance to the avatar • Display (tablet, AR)	• Accuracy to locate gaze	• Angular error

Next steps

- Literature review ongoing… (Merino et al. [2020], Halbig and Latoschik [2021], …)
  - Any pointer to related works is more than welcome!
- Identify interested people/groups:
  - UPM (Spain), Nokia Bell-Labs (Spain), CWI (The Netherlands), RISE (Sweden), TU Ilmenau (Germany), Ghent University (Belgium), Wuhan University (China), University of Surrey (United Kingdom), AGH University of Science and Technology (Poland), University of Brasilia, Meta (US).
  - **You?**
- Available systems to be evaluated:
  - CWI SocialVR, Nokia Owl, UPM FVV Live, RISE Crane control
  - **More?**
- Possible collaboration (liaison) with ITU-T SG12 P.QXM
  - Work on a common test plan?

References

- Brunnström et al. [2020] – “Latency impact on Quality of Experience in a virtual reality simulator for remote control of machines”, *Signal Processing: Image Communication 89*, 2020.
- Li et al. [2021] – “Evaluating the User Experience of a Photorealistic Social VR Movie”, *IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 2021.
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- Pan and Seed [2017] – “The impact of self-avatars on trust and collaboration in shared virtual environments”, *Plos One,* 2017.
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