Lecture 2:

Milgram et Al 1994

Augmented Reality: A class of displays on the reality-virtuality continuum

COMP 30025J

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Our First paper read

- I will first , ask the class about a section and go through my own notes on it.
- The final exam will be open book, and each question will normally refer to at least 2 papers but you can reference from any paper on the course .
- Word count wise, you should be aiming for around 800-900 words. (1000 is probably to ambitious)
- A 600 word answer that addresses the question would still get an A+ but it would be very hard to write that succinctly.
- Additional papers that you find while researching could be useful too if they back up your point.

Example Question

- "Why did Milgram's Reality-Virtuality Continuum succeed in becoming the standard taxonomy for Mixed Reality ?" (33 1/3 % , suggested 1000 words)

- Remember I will not use this question, now in the exam but I may write one similar to it .

Breakdown: Abstract

- From the Abstract this paper is about the following

1. Reality-Virtuality (RV) continuum
2. Different Mixed Reality display systems -> table
3. Three dimensional taxonomic framework
   - Extent of World Knowledge (EWK)
   - Reproduction Fidelity (RF)
   - Extent of Presence Metaphor (EPM)
4. Principal objective of the taxonomy classifying research across different disciplines

Breakdown: Introduction

From the Introduction

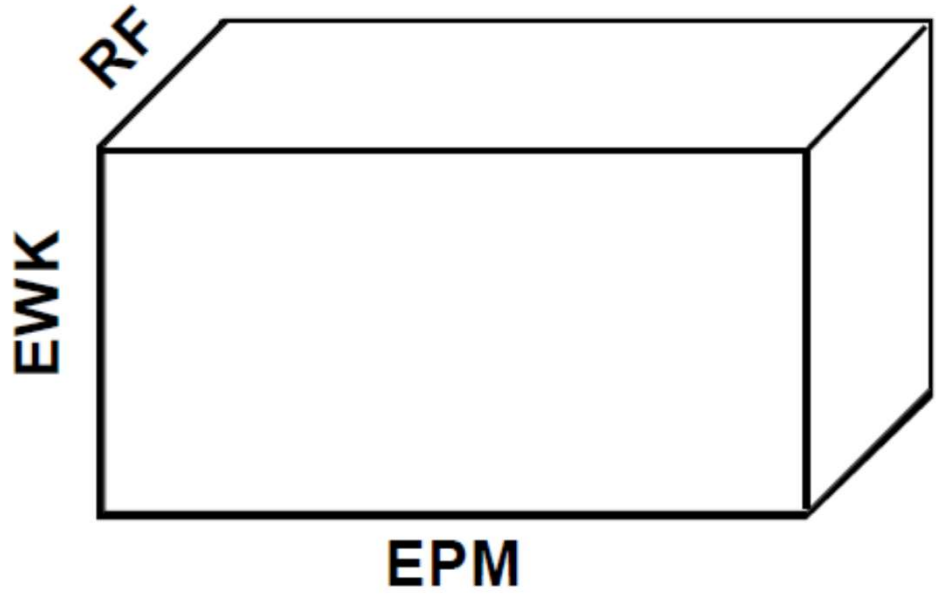
Section 2 will be REALITY-VIRTUALITY CONTINUUM
Section 3 will be about two principal manifestations of AR display systems: head-mounted see-through and monitor-based video AR displays
Section 4 will be discussion to MR systems in general, and provide a list of seven classes of MR displays
Section 5 will outline a formal taxonomy of mixed real and virtual worlds

Breakdown: Conclusions

Remember we don’t read in order unless there is a good reason to. So lets look at conclusions first
This paper says it does the following.

1. Reality-Virtuality (RV) continuum
2. Introduced Mixed Reality Term
3. Defined MR with 7 examples
4. Defined them using Extent of World Knowledge (EWK), Reproduction Fidelity (RF) and Extent of Presence Metaphor(EPM).
5. Gave VR developers, computer scientists and (tele)robotics engineers can now be placed within a single framework

Breakdown: Conclusions



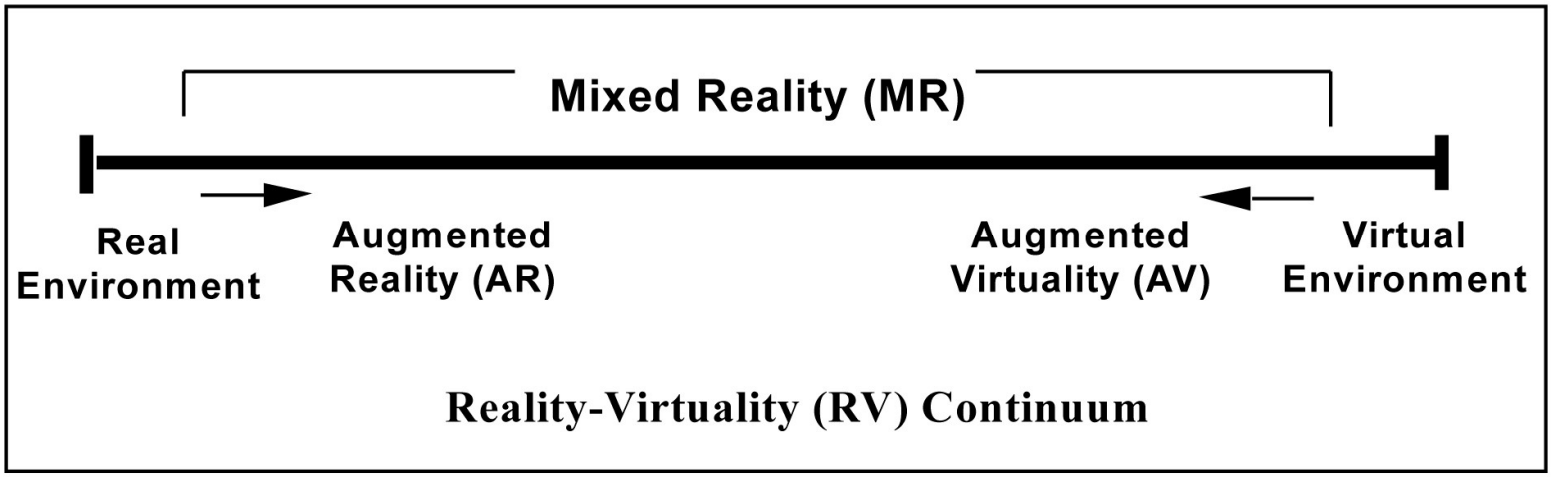
Is this a useful Concept ? , keep this in mind when you review the paper

Breakdown: References

Who are they referencing

T.P. Caudell and D.W. Mizell, "Augmented reality: An application of heads-up display technology to manual manufacturing processes". *Proc. IEEE Hawaii International Conf. on Systems Sciences*, 1992.
Essential references as in 1992 they had just patented the AR HMD design
S. Feiner, B. MacIntyre, and D. Seligmann, "Knowledge-based augmented reality". *Communications of the ACM, 36(7),* 52-62, 1993.
(Feiner and MacIntrye are well know so it makes sense they are referencing them)
H. Fuchs, M. Bajura, and R. Ohbuchi, "Merging virtual objects with the real world: Seeing ultrasound imagery within the patient." *Video Proceedings of IEEE Virtual Reality International Symposium (VRAIS'93),* Seattle, WA, 1993.
Lots of self references (this is a plus and a minus as these links are sometimes redundant but citations are key to academics careers so even if redundant they are going to make them.
Finally they reference other peoples attempts at this taxonomy recognizing that they are not the only ones looking into this area.

Section 2



Paper defines its AXIOMS(a statement or proposition that is regarded as being established, accepted, or self-evidently true.)

"AR as "a form of *virtual reality* where the participant's *head-mounted display* is transparent, allowing a clear view of the real world""

This paper asks

What is the relationship between Augmented Reality (AR) and Virtual Reality (VR)?

Should the term Augmented Reality be limited solely to transparent see-through head-mounted displays?

Section 3

Discusses the Concept of Augmented Reality Displays

Two important subsections
3.1 discusses “See Through” displays
3.2 Discusses “Monitor Based AR displays

Section 4

THE GENERAL CASE: MIXED REALITY ENVIRONMENTS

1. Monitor-based (non-immersive) AR displays, upon which computer graphic (CG) images are overlaid.
2. Same as 1, but using immersive HMD-based displays, rather than WoW monitors.§
3. HMD-based AR systems, incorporating optical see-through (ST).
4. HMD-based AR systems, incorporating video ST.
5. Monitor-based AV systems, with CG world substratum, employing superimposed video reality.
6. Immersive or partially immersive (e.g. large screen display) AV systems, with CG substratum, Employing superimposed video or texture mapped reality.
7. Partially immersive AV systems, which allow additional real-object interactions, such as 'reaching in‘ and 'grabbing' with one's own (real) hand.

Section 4: Table

Class of MR System	Real (R) or CG world?	Direct (D) or Scanned (S) view of substrate ?	Exocentric (EX) or Egocentric (EG) Reference?	Conformal Mapping (1:1), or not (1:k) ?
1. Monitor-based video, with CG overlays	R	S	EX	1:k
2. HMD-based video, with CG overlays	R	S	EG	1:k
3. HMD-based optical ST, with CG overlays	R	D	EG	1:1
4. HMD-based video ST, with CG overlays	R	S	EG	1:1
5. Monitor/CG-world, with video overlays	CG	S	EX	1:k
6. HMD/CG-world, with video overlays	CG	S	EG	1:k
7. CG-based world, with real object intervention	CG	D, S	EG	1:1

Table 1: Some major differences between classes of Mixed Reality (MR) displays.

Section 5

A TAXONOMY FOR MIXING REAL AND VIRTUAL WORLDS

Reality; that is, some environments are primarily virtual, in the sense that they have been created artificially, by computer, while others are primarily real.
Immersion; that is, virtual and real environments can each be displayed without the need for the observer to be completely immersed within them.
Directness; that is, whether primary world objects are viewed directly or by means of some electronic synthesis process.

Section 5 : **EWK**

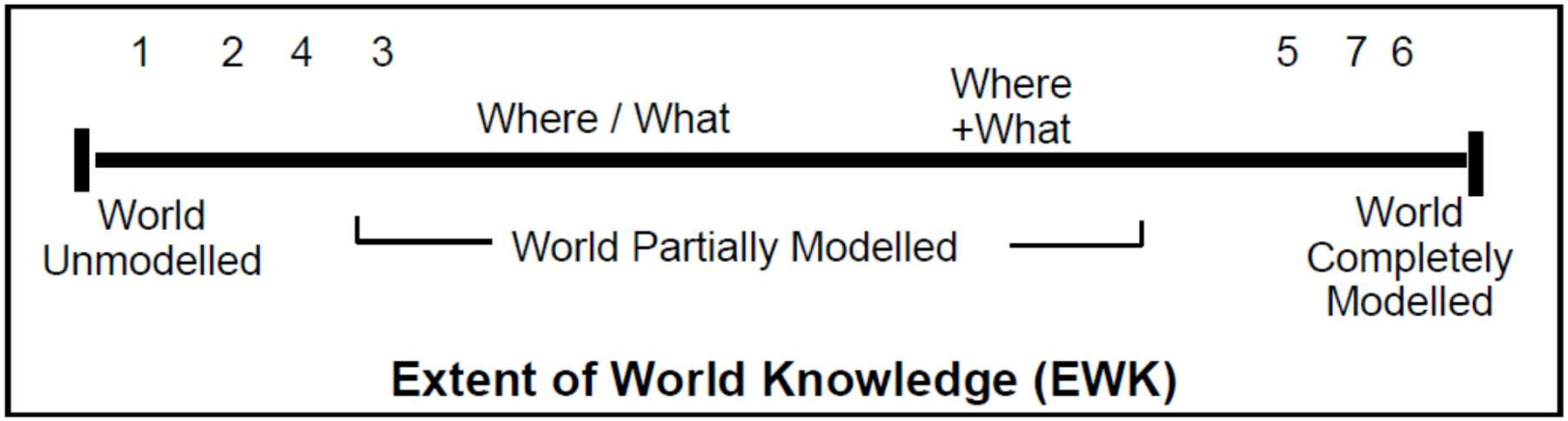


Figure 2: Extent of World Knowledge (EWK) dimension

Section 5: RF

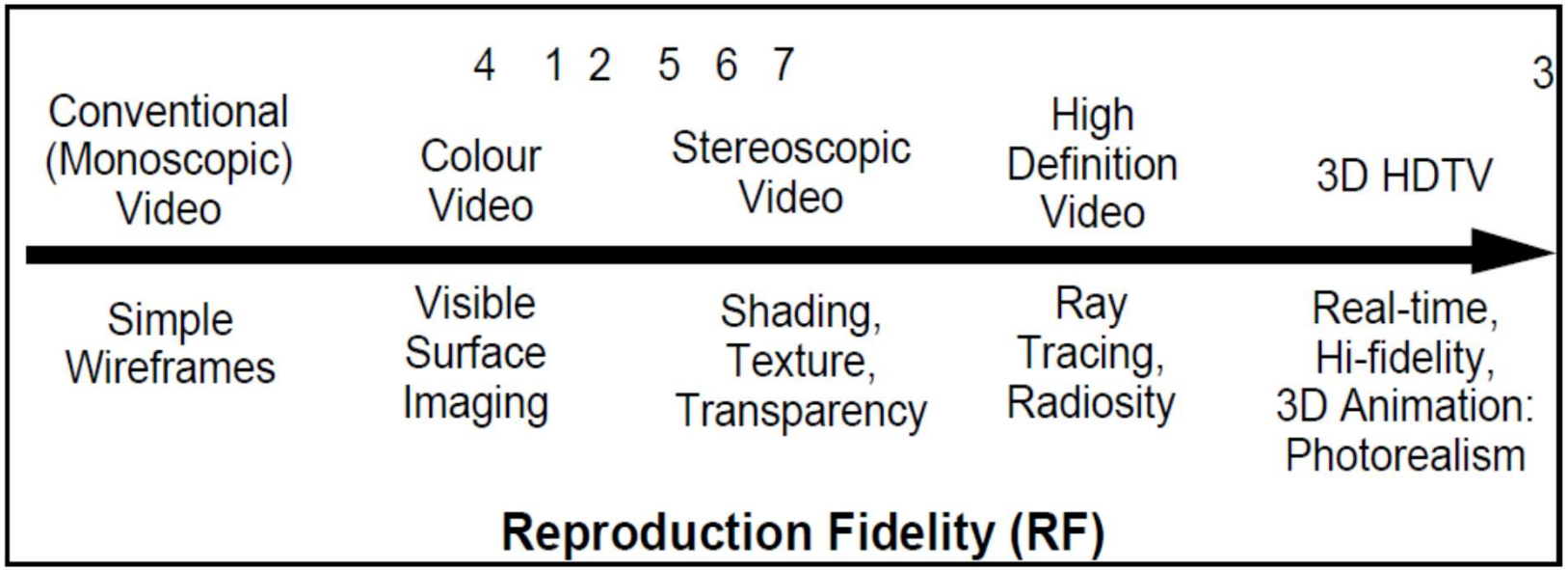


Figure 3: Reproduction Fidelity (RF) dimension.

Section 5:**EPM**

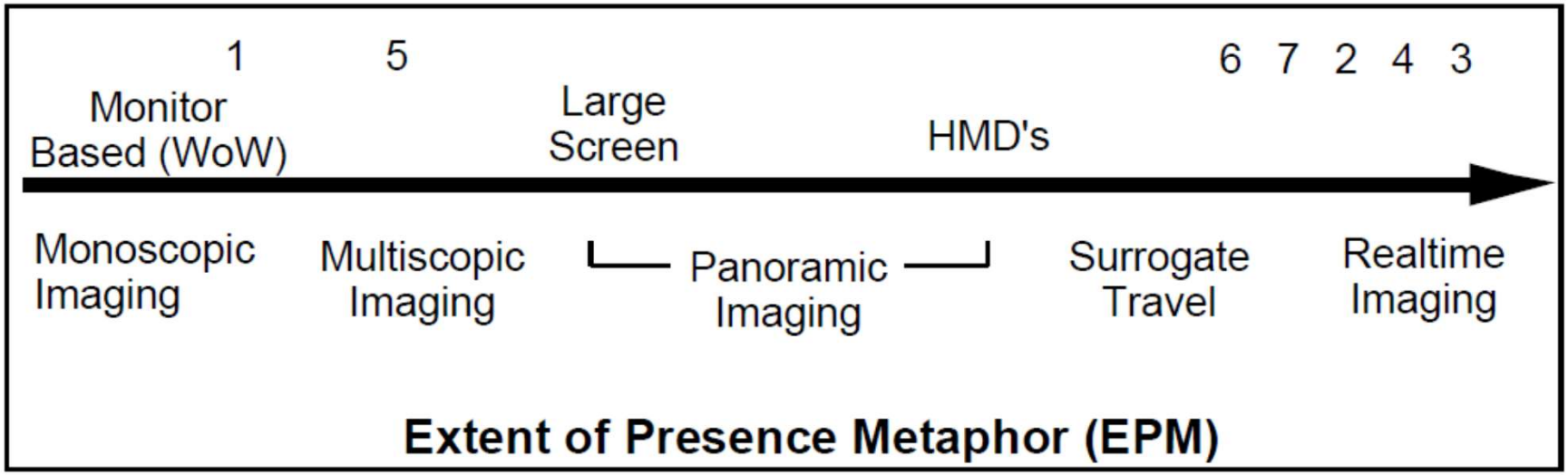
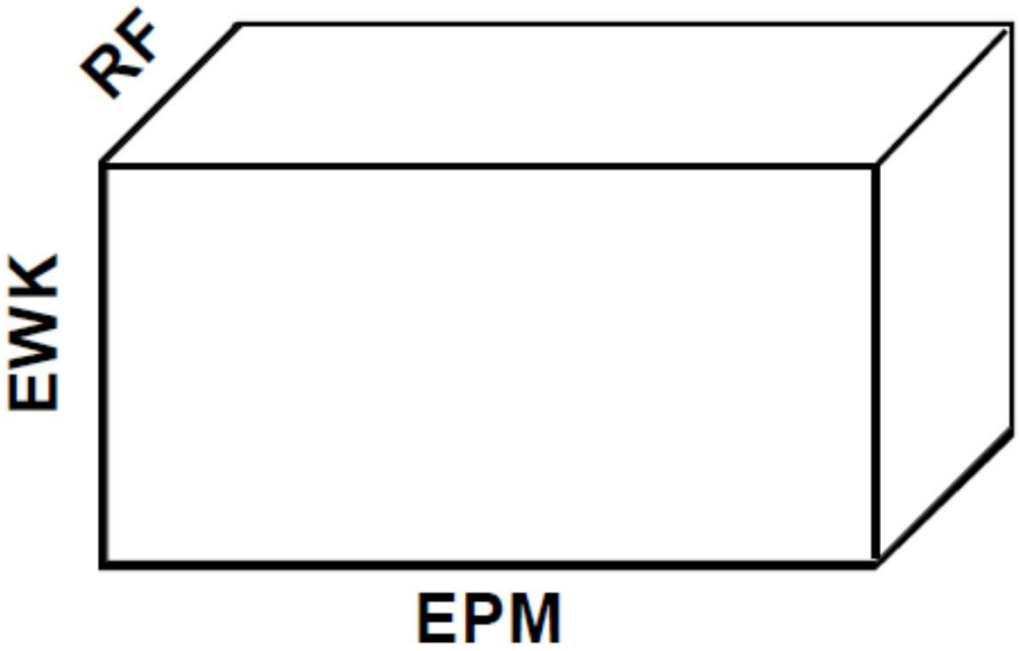


Figure 4: Extent of Presence Metaphor (EPM) dimension

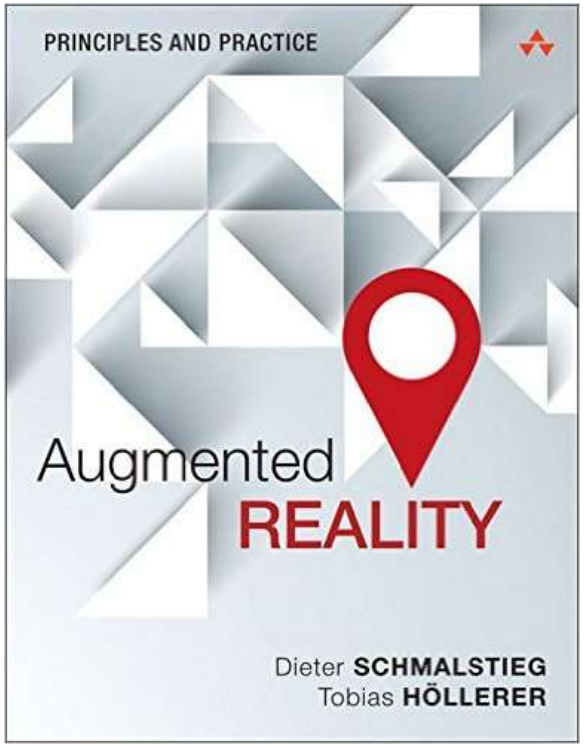
Combining these 3 Taxonomies



What can we learn from this ?

Textbook Recommendation

- Please read Chapter 1



Next Weeks paper

A Survey of Augmented Reality Technologies, Applications and Limitations (2010) by D.W.F. van Krevelen and R. Poelman

Its a reasonable update addtion to the more famous papers from Azuma (1997) and Azuma et Al (2001)