



Virtual and Augmented Reality Applications for Human Behaviour in Disasters: A Review



FEMTC 2020

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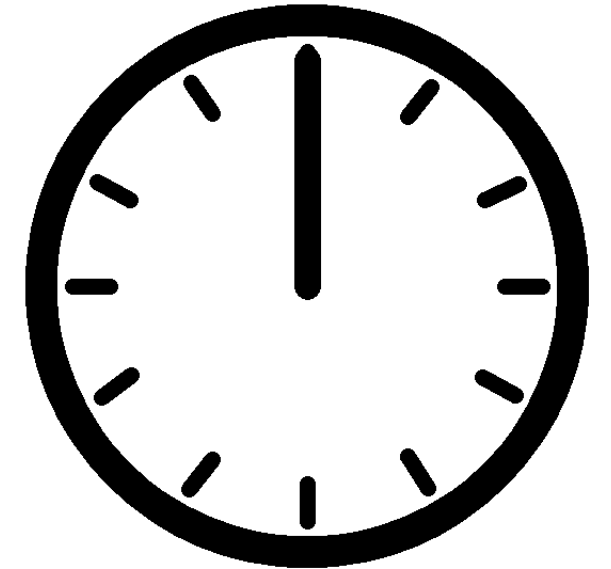


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Outlines

- **Definition of VR and AR**
- **Review Approach**
- **VR and AR for Safety Design**
- **VR and AR for Behavioural Investigation**
- **VR and AR for Training**
- **Conclusions**



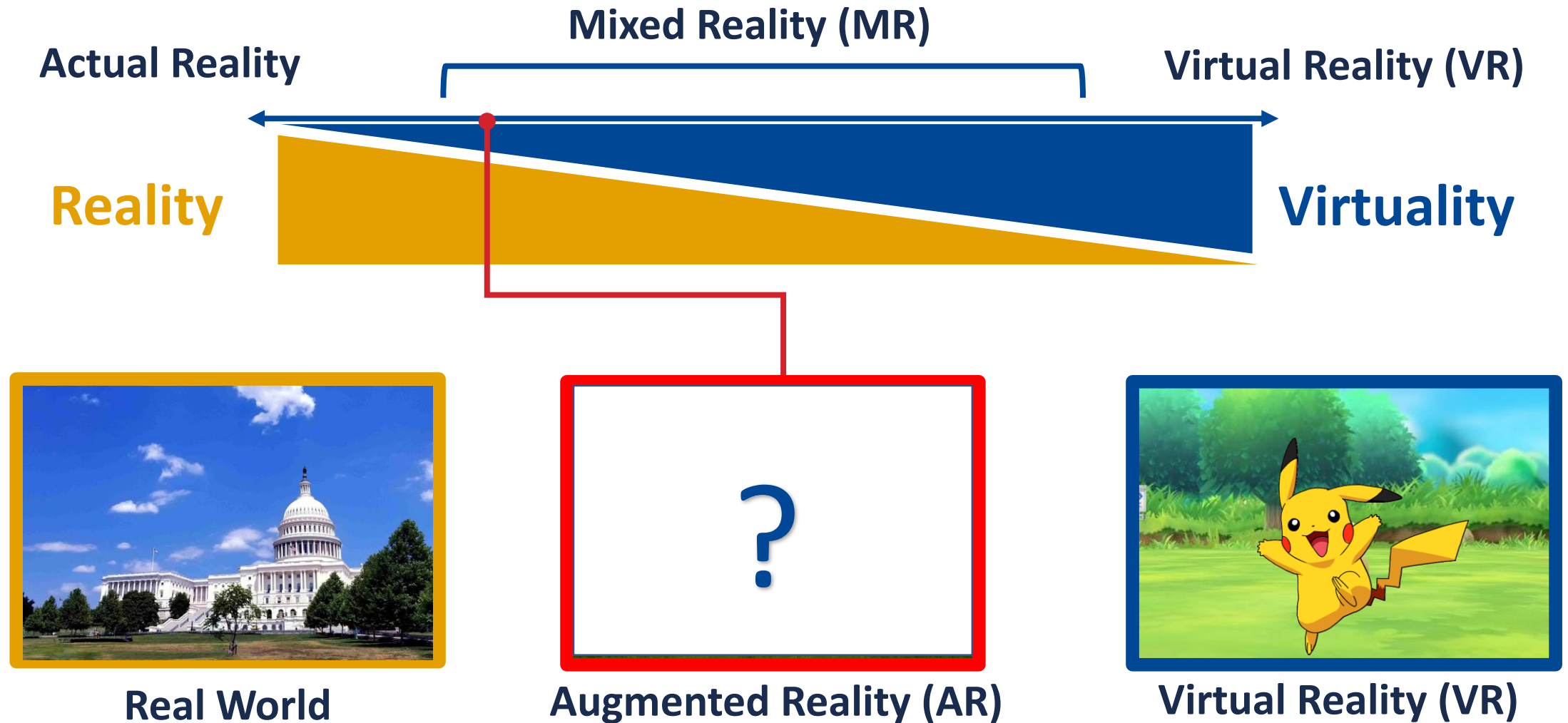
Let us get started!

What is VR and AR?

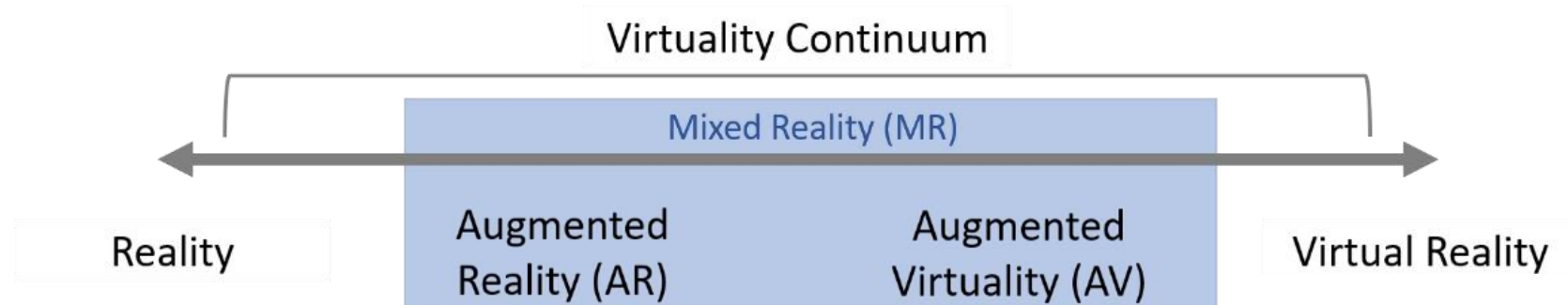


Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *EICE Transactions on Information Systems*.

What is VR and AR?



Virtual Reality



How many have experience Virtual Reality?



How many have experience Augmented Reality?



Existing Review works

(Feng et al., 2018; Kinateder, Ronchi, Gromer, et al., 2014; Lovreglio R & Kinateder M, 2020)



Keywords:

Virtual Reality OR Augmented Reality AND Evacuation

Virtual Reality OR Augmented Reality AND Evacuation Training

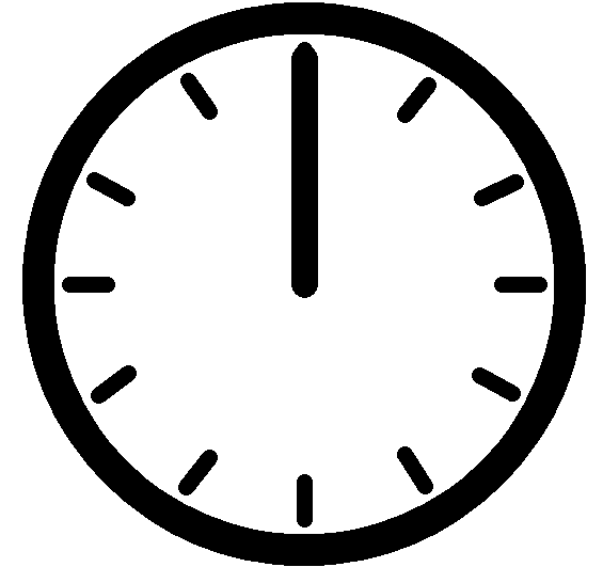
In or Out Criteria:

- (a) An AR or VR application for building evacuation was proposed;
- (b) An AR or VR application was tested through experiments.



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What can we do with VR?

Test new emergency systems

Investigate human behaviour

Train people

Reference	Hardware setup	Type of Disaster	Design Aim
(E. Ronchi et al., 2016)	VR-CAVE	Tunnel fire	Exit portals
(Cosma, Ronchi, & Nilsson, 2016)	VR-HMD	Tunnel fire	Way-finding systems
(Arias, La Mendola, et al., 2019)	VR-HMD	Tunnel fire	Way-finding systems
(Enrico Ronchi et al., 2019)	VR-CAVE VR-HMD	Road tunnel fire	Exit portals
(Olander, Ronchi, Lovreglio, & Nilsson, 2017)	VR-Non immersive	Building fire	Dissuasive exit signs
(Enrico Ronchi, Nilsson, Modig, & Walter, 2016)	VR-Non immersive	Tunnel fire	Message sign designs
(Mossberg, Nilsson, & Wahlqvist, 2020)	VR-HMD	Underground station fire	Way-finding systems and elevator signs
(Andrée, Nilsson, & Eriksson, 2016)	VR-CAVE	Building fire	Way-finding systems
(Kinateder, Warren, & Schloss, 2019)	VR-HMD	Building fire	Exit signs
(Tang, Wu, & Lin, 2009)	VR -Non immersive	Building fire	Way-finding systems
(Occhialini et al., 2016)	VR -Non immersive	Building fire	Exit signs
(Kostakos et al., 2020)	VR-HMD	Underground parking lot fire	Way-finding systems
(Duarte, Rebelo, Teles, & Wogalter, 2014)	VR-HMD	Explosion/fire	Safety signs
(Lochhead & Hedley, 2018)	AR-VST	General evacuation	Building Evacuation design
(Ahn & Han, 2012)	AR-VST	General evacuation	Way-finding systems
(Tsai & Yau, 2013)	AR-VST	Radioactive accidents	Way-finding systems
(Ortakci, Atila, Demiral, Ozacar, & Karas, 2017)	AR-VST	Building fire	Way-finding systems
(Stigall & Sharma, 2017)	AR-VST	Building fire	Way-finding systems
(Diao & Shih, 2018)	AR-VST	General evacuation	Way-finding systems
(Mitsuhara, Tanimura, Nemoto, & Shishibori, 2019)	AR-VST	General evacuation	Way-finding systems
(Kitamura, Yasui, & Nakatani, 2019)	AR-VST	General evacuation	Way-finding systems
(Catal, Akbulut, Tunali, Ulug, & Ozturk, 2019)	AR-VST	General evacuation	Way-finding systems
(Cai, Yang, & Tao, 2018)	AR-OST	General evacuation	Way-finding systems

What can we do with VR?

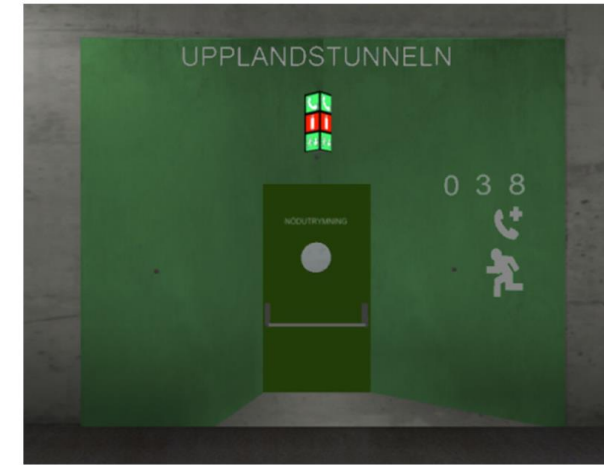


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CAVE System

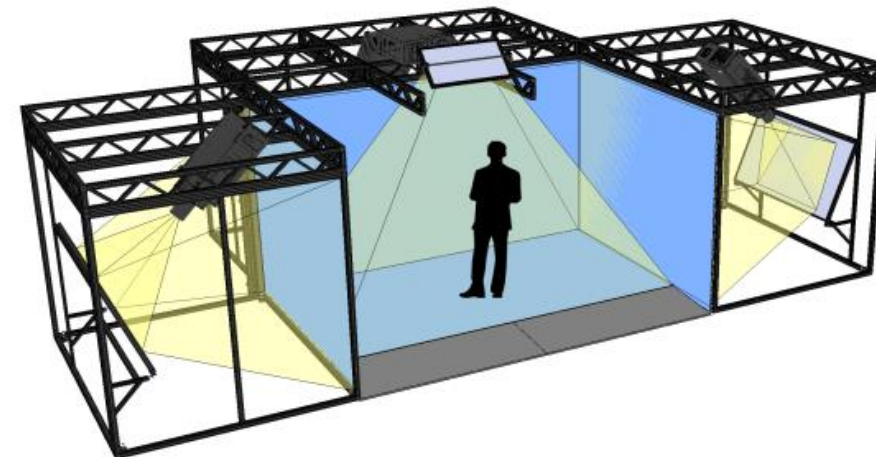
An example of portals



Dr Ronchi



Prof Nilsson



What can we do with VR?



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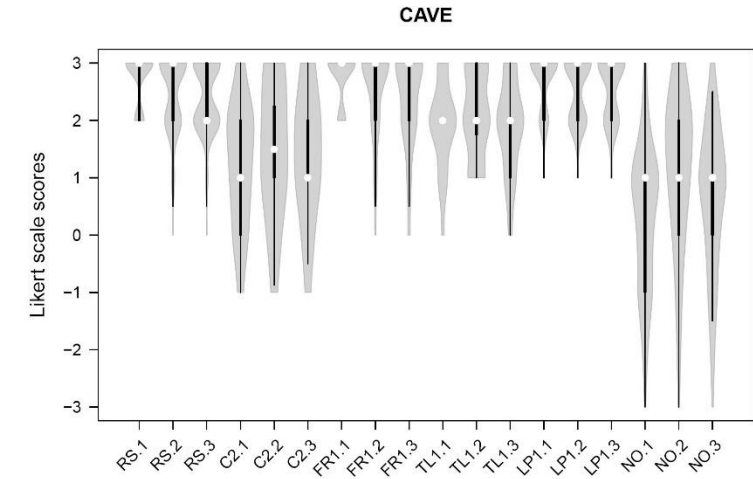
Train people



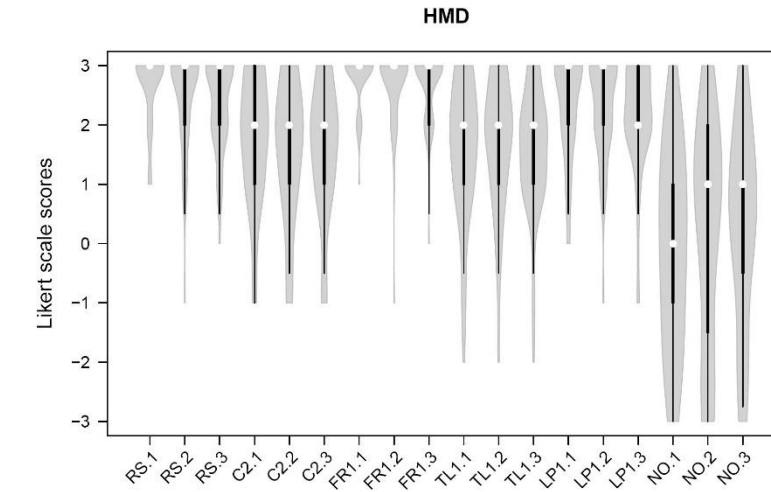
CAVE System



Smartphone VR



~ similarity!

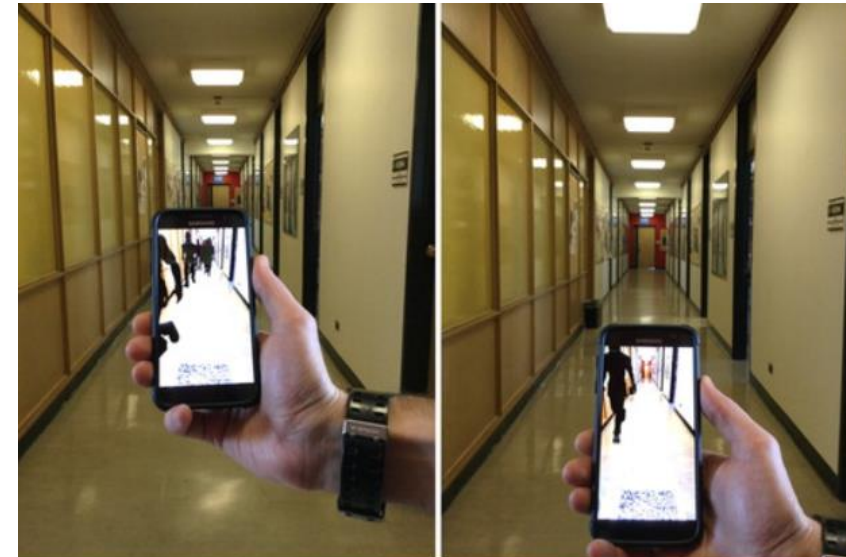
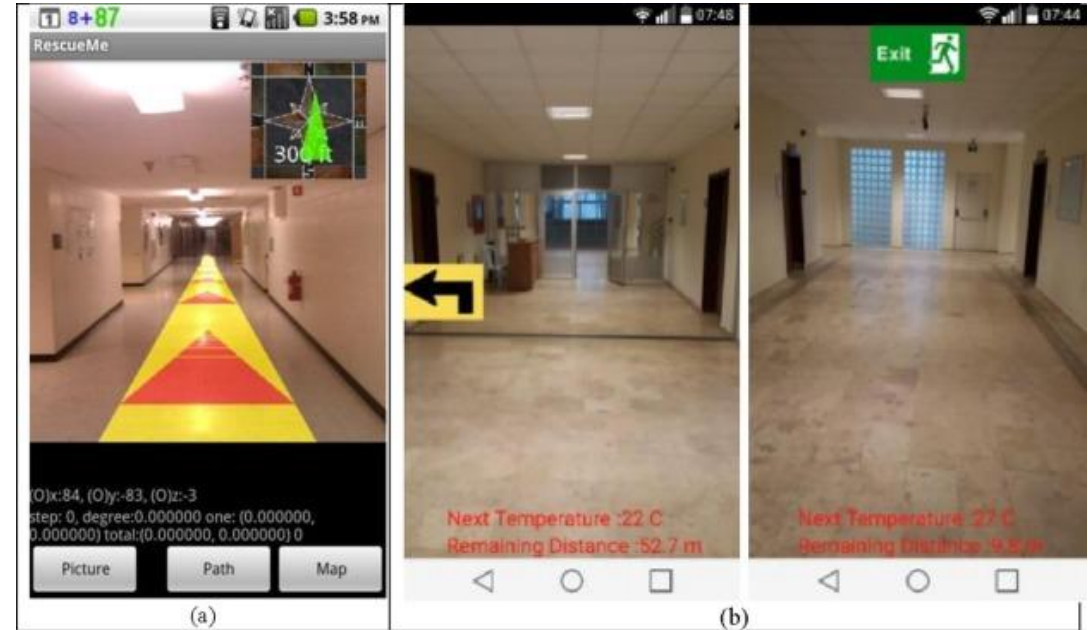


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Reference	Hardware setup	Type of Disaster	Behaviors under investigation
(Lin, Zhu, Li, & Becerik-Gerber, 2020)	VR-HMD	Underground station fire	Exit/Route choice
(Zhu, Lin, Becerik-Gerber, & Li, 2020)	VR-HMD	Underground station fire	Exit/Route choice
(Wetterberg, Ronchi, & Wahlqvist, 2020)	VR-HMD	Wildfire	Driving behavior
(Cao, Lin, & Li, 2019)	VR-HMD	Building fire	Exit/Route choice
(Kinateder et al., 2015)	VR-CAVE	Tunnel fire	Exit/Route choice
(Kinateder & Warren, 2016)	VR-HMD	Building fire	Pre-evacuation
(Kobes, Helsloot, de Vries, & Post, 2010)	VR-Non immersive	Building fire	Exit/Route choice and pre-evacuation
(Tucker et al., 2018)	VR-Non immersive	Building fire	Exit/Route choice
(Kinateder, Müller, Jost, Mühlberger, & Pauli, 2014)	VR-CAVE	Tunnel fire	Exit/Route choice
(Feng, González, Trotter, et al., 2020)	VR-HMD	Earthquake	Exit/Route choice and pre-evacuation
(Bourhim & Cherkaoui, 2020)	VR-HMD	Building fire	Pre-evacuation and response behaviours
(Kinateder, Ronchi, Gromer, et al., 2014)	VR-CAVE	Tunnel fire	Exit/Route choice
(Kinateder, Comunale, & Warren, 2018)	VR-HMD	Building fire	Exit/Route choice
(Arias, Nilsson, & Wahlqvist, 2020)	VR-HMD	Building fire	Pre-evacuation and
(Arias, Fahy, et al., 2019)	VR-HMD	Building fire	Pre-evacuation
(Enrico Ronchi et al., 2015)	VR-CAVE	Tunnel fire	Exit/Route choice
(Andrée et al., 2016)	VR-CAVE	Building fire	Exit/Route choice and waiting time at the elevator
(Shih, Lin, & Yang, 2000)	VR-Non immersive	Building fire	Exit and route choice
(Shih et al., 2000)	VR-Non immersive	Building fire	Exit/Route choice
(Fujimi & Fujimura, 2020)	VR-HMD	Flood	Pre-evacuation
(Aleksandrov, Rajabifard, Kalantari, Lovreglio, & González, 2018)	VR-Non immersive	Building fire	Exit/Route choice
(Meng & Zhang, 2014)	VR-Non immersive	Building fire	Exit/Route choice
(Drury et al., 2009)	VR-Non immersive	Underground station fire	Navigation and other behaviours
(R. Lovreglio, Ronchi, & Nilsson, 2015)	VR-CAVE	Tunnel fire	Navigation
(Ruggiero Lovreglio et al., 2014)	VR-Non immersive	Building fire	Exit/Route choice
(R. Lovreglio, Fonzone, & Dell'Olio, 2016)	VR-Non immersive	Building fire	Exit/Route choice

Exit Choice Behaviour

Safety Science 62 (2014) 418–426



Contents lists available at [ScienceDirect](#)

Safety Science

journal homepage: www.elsevier.com/locate/ssci



A discrete choice model based on random utilities for exit choice in emergency evacuations

Ruggiero Lovreglio^{a,*}, Dino Borri^a, Luigi dell'Olio^{b,*}, Angel Ibeas^b

Safety Science 82 (2016) 421–431



Contents lists available at [ScienceDirect](#)

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A study of herding behaviour in exit choice during emergencies based on random utility theory

Ruggiero Lovreglio^{a,*}, Achille Fonzone^b, Luigi dell'Olio^c, Dino Borri^a

Transportation Research Part A 92 (2016) 59–75



Contents lists available at [ScienceDirect](#)

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra



A mixed logit model for predicting exit choice during building evacuations

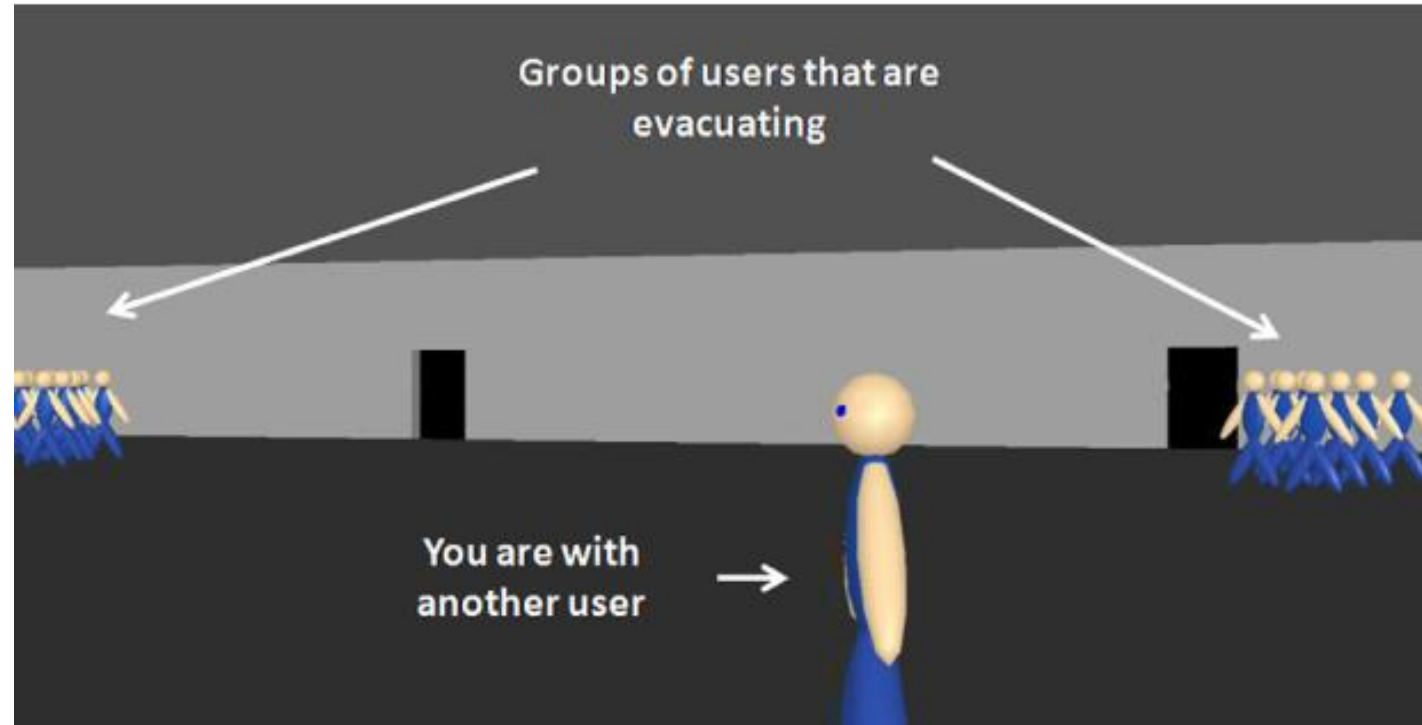
Ruggiero Lovreglio^{a,*}, Achille Fonzone^b, Luigi dell'Olio^c



^aDepartment of Civil, Environmental, Planning, Building and Chemistry, Politecnico di Bari, Via Edoardo Orabona, 4, 70126 Bari, Italy

^bTransport Research Institute, Edinburgh Napier University, 10 Colinton Road, Edinburgh EH10 5DT, United Kingdom

^cTransport Systems Research Group, Universidad de Cantabria, Avda. de los Castros, s/n 39005, Santander, Spain



My VR 10 year ago
using FDS+Evac

Exit Choice Behaviour

VIDEO 1/6



Exit Choice Behaviour

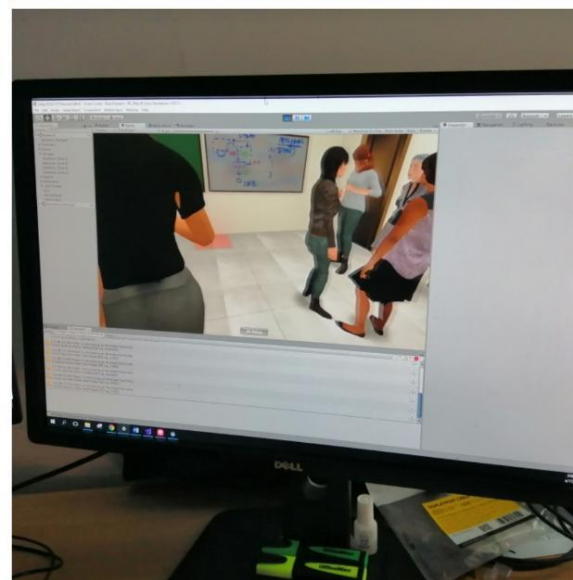
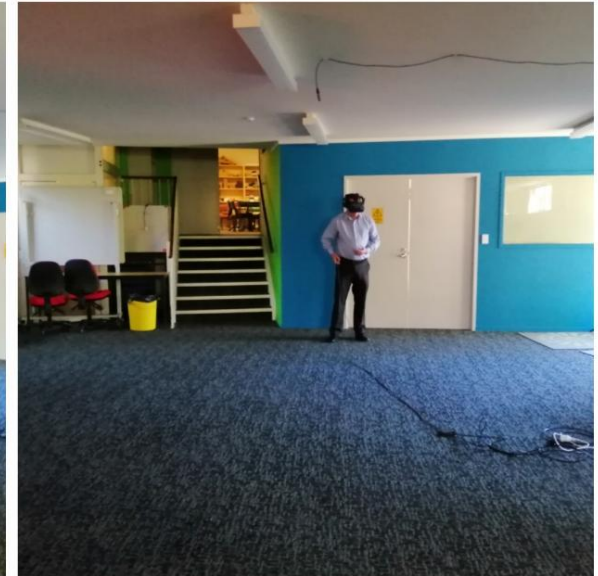
Test new emergency systems

Investigate human behaviour

Train people



Dr (to be) Rahouti



Exit Choice Behaviour

Unity 2018.2.11f1 Personal (64bit) - Scene 0.unity - Base Scenario - PC, Mac & Linux Standalone <DX11>

File Edit Assets GameObject Component Mobile Input Window Help

Center Local [Play] [Pause] [Stop] Collab Account Layers Layout

Game Display: Free Aspect Scale 1x Left Eye Maximize On Play Mute Audio Stats Gizmos



Exit Choice Behaviour

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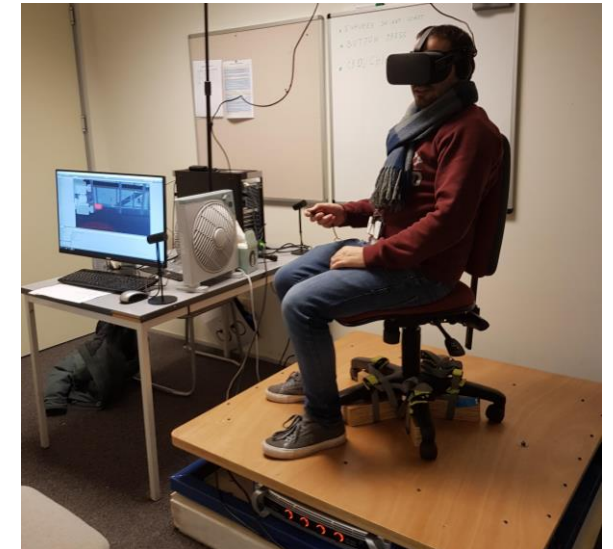
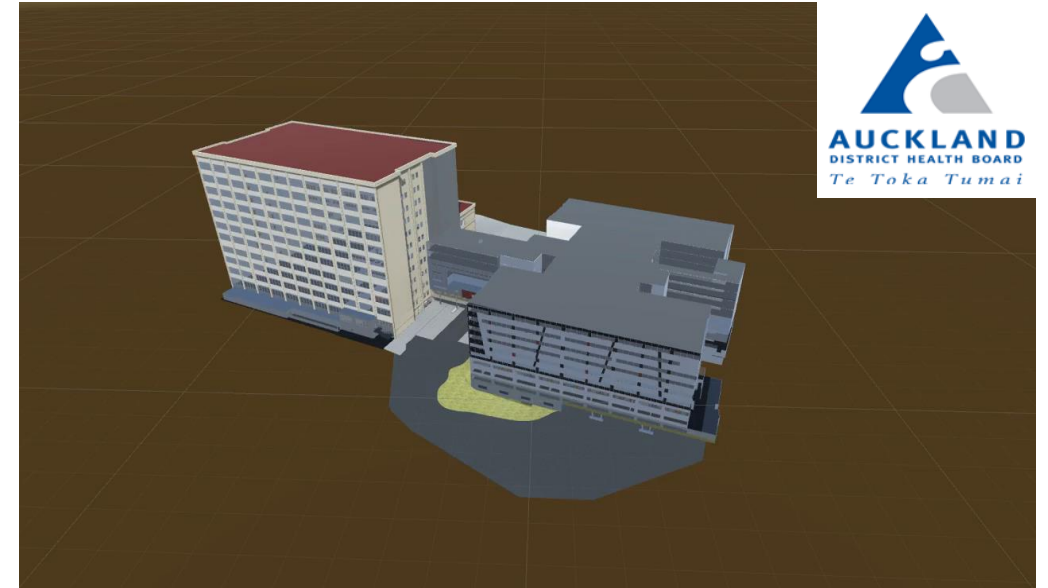
What can we do with VR?



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Reference	Hardware setup	Type of Disaster	Training Goals
(Feng, González, Mutch, et al., 2020)	VR-HMD	Earthquake	Earthquake preparedness
(Mitsuhara & Shishibori, 2020)	VR-HMD AR- VST	Tornado	Tornado awareness
(Li, Liang, Quigley, Zhao, & Yu, 2017)	VR-HMD	Earthquake	Drop cover and hold
(Ruggiero Lovreglio, Duan, Rahout, Phipps, & Nilsson, 2020)	VR-HMD	Building fire	Use of fire extinguishers
(Månsson & Ronchi, 2018)	VR-HMD	Building fire	Use of fire extinguishers
(Feng et al., 2019)	VR-HMD	Earthquake	Earthquake preparedness
(Burigat & Chittaro, 2016)	VR-HMD	Aircraft accident	Location of emergency exits
(Chittaro & Buttussi, 2015)	VR-HMD	Aircraft accident	Brace position and evacuation procedures
(Smith & Ericson, 2009)	VR-CAVE	Building Fire	Fire evacuation procedures
(Kinatered et al., 2013)	VR-CAVE	Tunnel Fire	Fire safety behaviors
(Farra et al., 2019)	VR-Non immersive VR- HMD	Building Fire	Evacuation of neonates
(López, Plá, Méndez, & Gervás, 2010)	AR-VST	Building Fire	Fire evacuation procedures
(Kawai, Mitsuhara, & Shishibori, 2016)	AR-VST	Tsunami and earthquake	Evacuation procedures
(Mitsuhara, Shishibori, Kawai, & Iguchi, 2016)	AR-VST	Tsunami	Evacuation procedures
(Mitsuhara, Iguchi, & Shishibori, 2017)	AR-VST AR-OST	Earthquake	Earthquake preparedness
(Mitsuhara, Iwaka, et al., 2017)	AS-VST	Tsunami and earthquake	Evacuation procedures
(Sharma, Bodempudi, Scribner, Grynovicki, & Grazaitis, 2019)	AR-VST AR-OST	Building fire	Location of emergency exits

What can we do with VR?



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Remember the **PASS** Word

Pull

Pull the pin (or other motion) to unlock the extinguisher.



Aim

Aim at the base (bottom) of the fire and stand 6 - 10 feet away.



Squeeze

Squeeze the lever to discharge the agent.



Sweep

Sweep the spray from left to right until the flames are totally extinguished.



What can we do with VR?

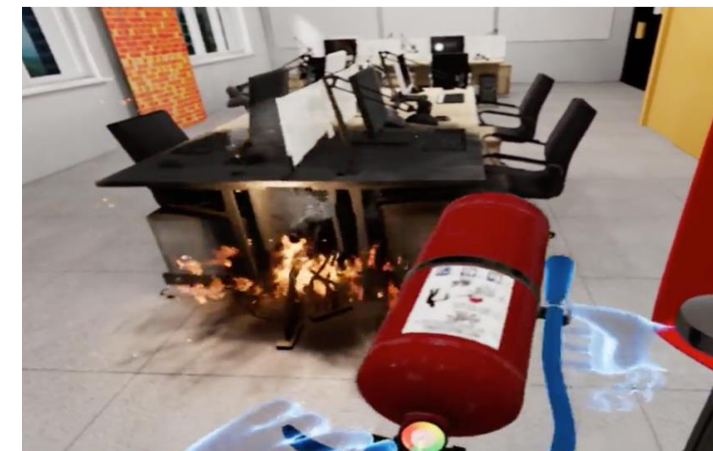


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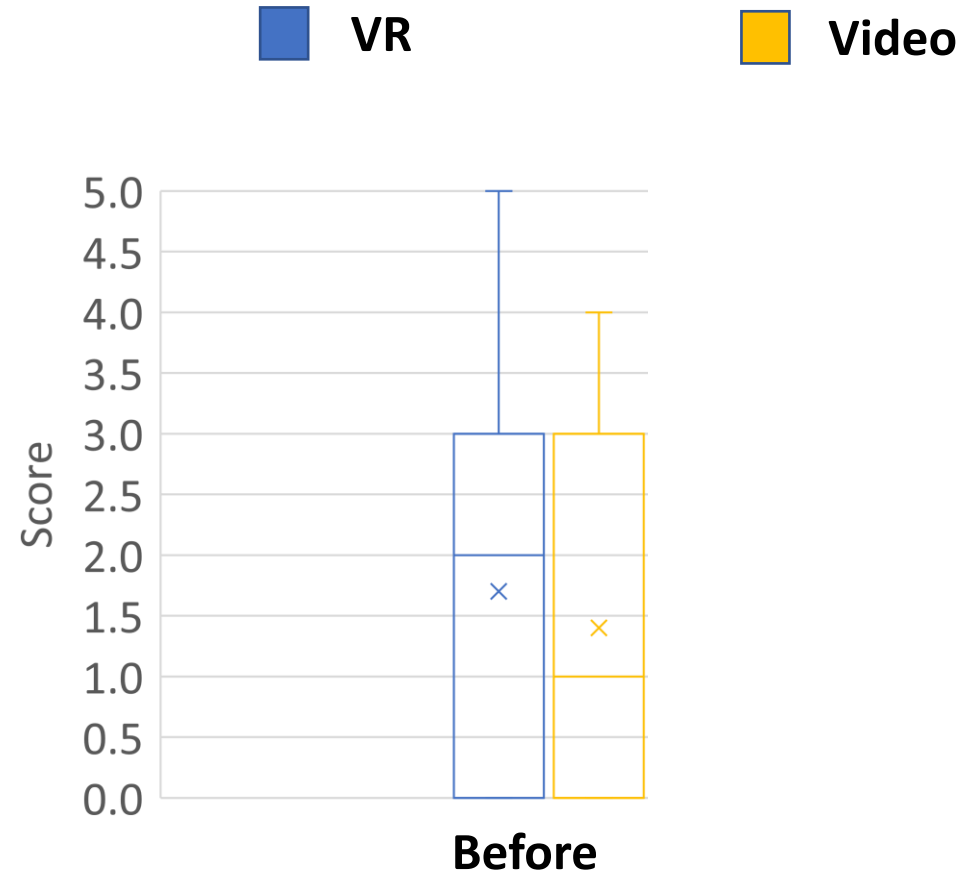


What can we do with VR?

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Video source:

<https://www.youtube.com/watch?v=6NMUuteWvRo>

What can we do with VR?



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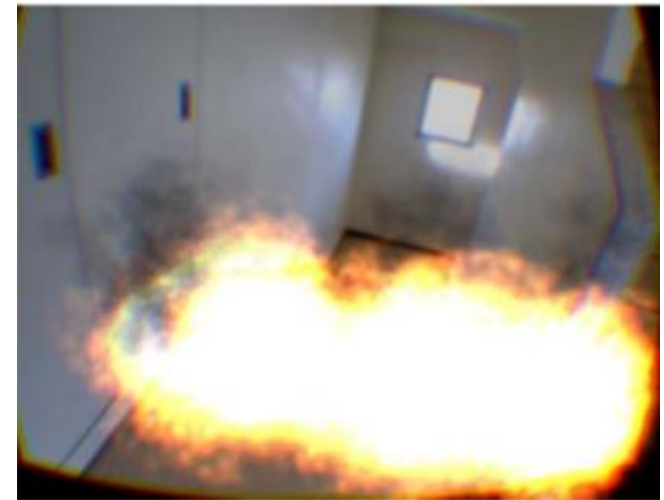
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An injured person



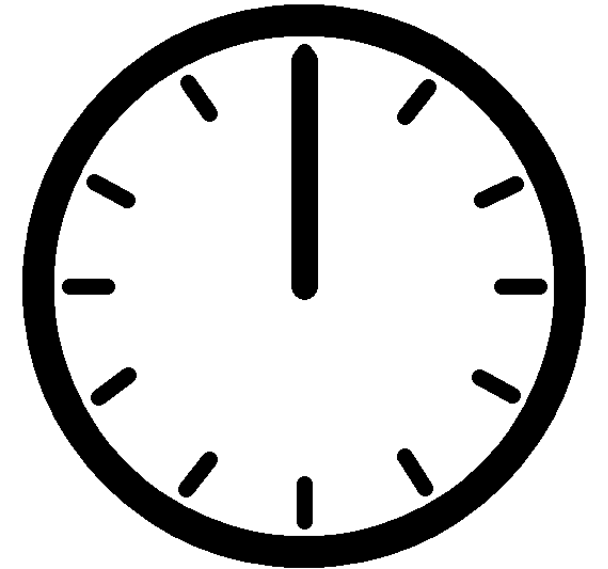
Outlines

Conclusions

Many applications to learn from. However the best path is learning by doing it.

There are many open questions: validation, comparison and effectiveness of VR and AR

VR and AR have a lot of potentialities and they can be applied in many more disasters and case studies



1. Lovreglio R, 2020, Virtual and Augmented Reality For Human Behaviour In Disasters: A Review, *FEMTC 2020*
2. All the papers in 1
3. Feng, Z., González, V. A., Amor, R., Lovreglio, R., & Cabrera-Guerrero, G. (2018). Immersive virtual reality serious games for evacuation training and research: A systematic literature review. *Computers & Education*, 127, 252–266. <https://doi.org/10.1016/J.COMPEDU.2018.09.002>
4. Kinaterer, M., Ronchi, E., Nilsson, D., Kobes, M., Müller, M., Pauli, P., & Mühlberger, A. (2014). Virtual Reality for Fire Evacuation Research. *Computer Science and Information Systems (FedCSIS)*, 313–321. <https://doi.org/10.15439/2014F94>
5. Lovreglio, R., & Kinaterer, M. T. (2020). Augmented Reality for Pedestrian Evacuation Research: Promises and Limitations. *Safety Science*, 128, 104750. <https://doi.org/10.1016/j.ssci.2020.104750>



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Many Thanks!

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