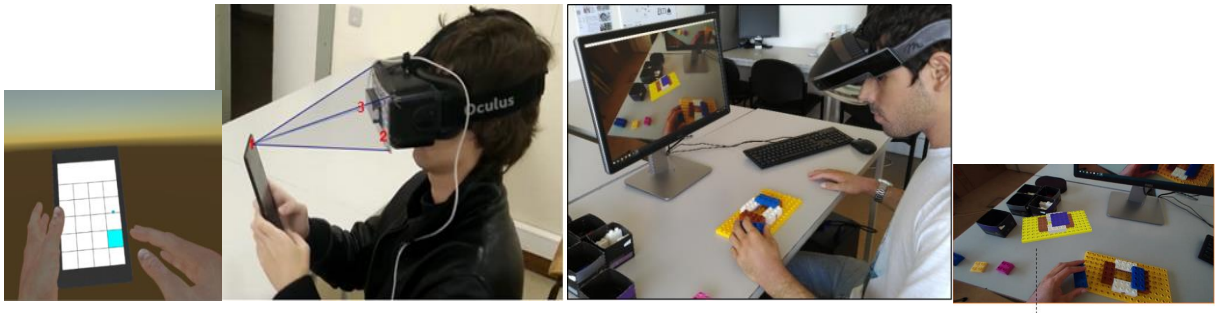
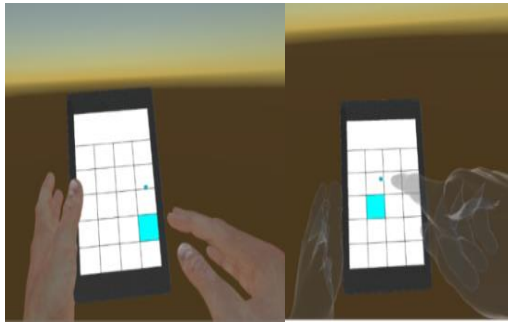
Universidade de Aveiro
Departamento de Electrónica,
Telecomunicações e Informática

Evaluation in VR and AR examples



I - Studying the effect of hand-avatars in a immersive VE using a tablet as input device for a selection task



Motivation

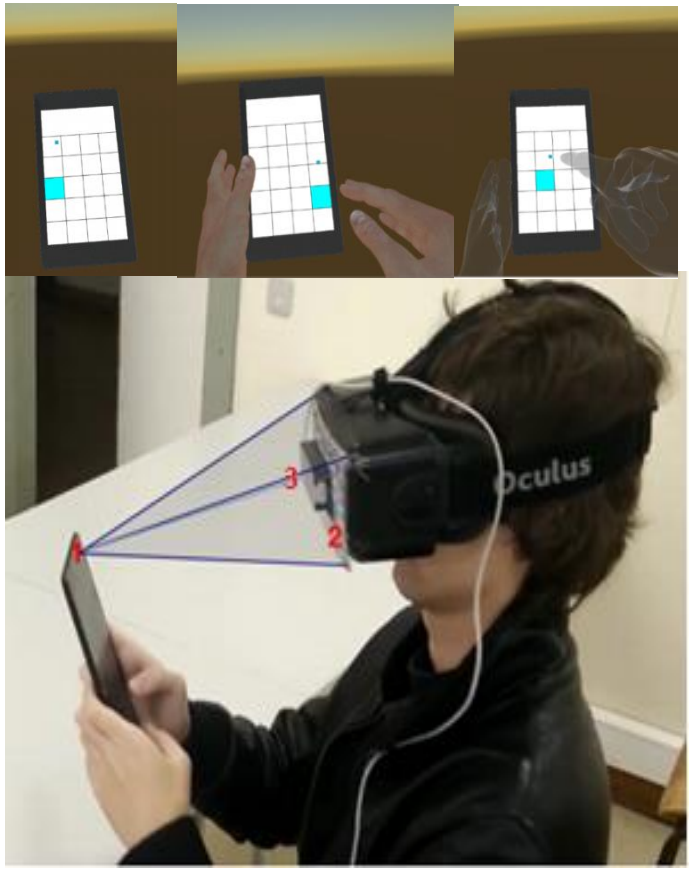
- Mobile devices have already been used as input to perform interactions in VEs
- Literature suggests their usage as input devices is viable and presents benefits
- The effect of using avatars in this situation is still an open issue

Luís Afonso, Paulo, Dias, Carlos Ferreira, Beatriz Sousa Santos, "Effect of Hand-Avatar in a Selection Task Using a Tablet as Input Device in an Immersive Virtual Environment". *IEEE Symposium on 3D User Interfaces (3DUI2017)*, Los Angeles, March 2017.
https://ieeexplore.ieee.org/document/7893364

I - Studying the effect of hand-avatars in a immersive VE using a tablet as input device for a selection task

- Task:

- Selecting as fast as possible a highlighted button from a group of 25 buttons on the virtual tablet screen



- Experimental Setup:

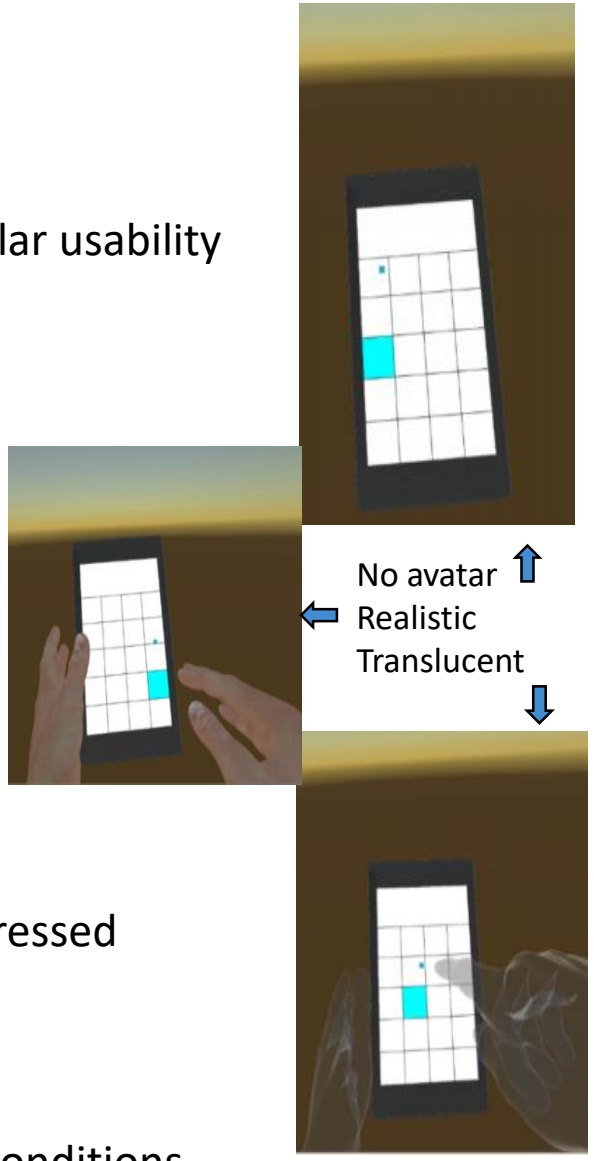
- Oculus + Tablet + Leap Motion
- Unity + Vuforia
- Tablet front camera (1) tracking
- AR marker on the Oculus (2)
- Leap Motion (3) mounted on Oculus providing hands tracking

- **Hypothesis** (Ho):

- All conditions concerning hand avatar have similar usability (performance and opinion)

- **Independent variable**: type of hand avatar (3 experimental conditions):

- No hand avatar
- Realistic hand avatar
- Translucent hand avatar



- **Dependent variables**: performance and opinion:

- Task completion time (seconds)
- Selection errors: number of incorrect buttons pressed
- Opinion (Likert-like scale)

- **Experimental design**: **within-groups** (all participants used the three experimental conditions in different order to compensate for learning)

- **Experimental procedure**:

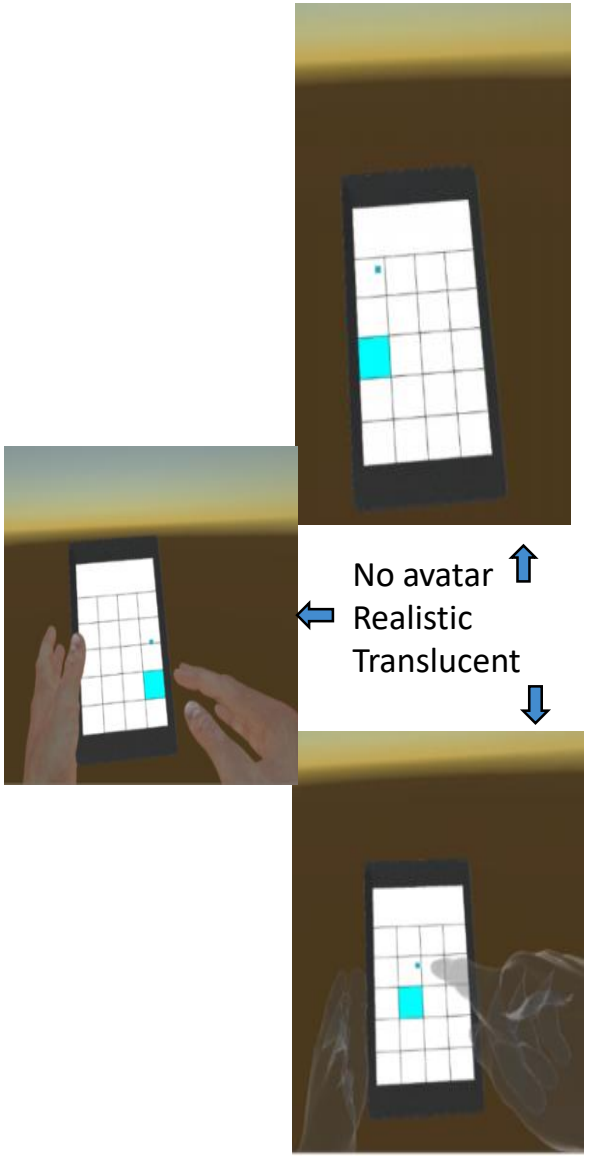
- Briefing about the experiment
- Familiarization with the setup
- Selecting 25 buttons
- Using three experimental conditions
- Questionnaire

- **Participants:**

- 55 students performed the tasks
- 52 answered the questionnaire
  (4 females; aged 19 to 28 years)
  (30 had never used VR before)

- Statistical analysis:

- Non parametric tests (Friedman) due to:
  - non normality of time and error data
  - ordinal nature of questionnaire data



Hand representation experiment questionnaire

1. **User ID:** _____
2. **What is your age?** _____
3. **What is your gender?** ☐ Female ☐ Male
4. **Have you used Virtual Reality before?**
   - ☐ Yes
   - ☐ No
5. **Dominant hand:**
   - ☐ Right
   - ☐ Left
6. **How often do you use smartphone/tablet devices:**
   Never ☐—☐—☐—☐—☐ Regularly
7. **Please rank the three modes by preference:**
   No Hands (1) _____
   Realistic Hands (2) _____
   Transparent Hands (3) _____
8. **Explain why the mode [1/2/3] was your favorite:**
   _____
   _____
   _____
   _____
9. **How much physical fatigue did you experience in your arms while interacting with the environment?**
   None ☐—☐—☐—☐—☐ Extreme

No Hand Representation

10. **The task was (1 difficult, 5 easy) to perform.**
    Difficult ☐—☐—☐—☐—☐ Easy
11. **I felt like I was able to interact with the tablet the way I wanted to.**
    Strongly Disagree ☐—☐—☐—☐—☐ Strongly Agree

Realistic Hand Representation

12. **The task was (1 difficult, 5 easy) to perform.**
    Difficult ☐—☐—☐—☐—☐ Easy
13. **I felt like I was able to interact with the tablet the way I wanted to.**
    Strongly Disagree ☐—☐—☐—☐—☐ Strongly Agree
14. **I felt as if the virtual representation of the hand moved just like I wanted it to.**
    Strongly Disagree ☐—☐—☐—☐—☐ Strongly Agree

Transparent Hand Representation

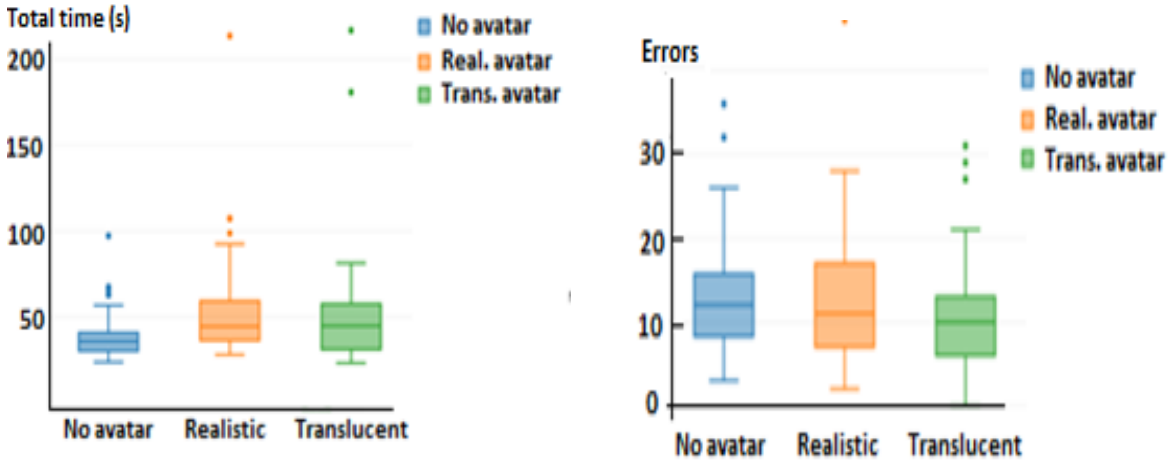
15. **The task was (1 difficult, 5 easy) to perform.**
    Difficult ☐—☐—☐—☐—☐ Easy
16. **I felt like I was able to interact with the tablet the way I wanted to.**
    Strongly Disagree ☐—☐—☐—☐—☐ Strongly Agree
17. **I felt as if the virtual representation of the hand moved just like I wanted it to.**
    Strongly Disagree ☐—☐—☐—☐—☐ Strongly Agree

18. **Comments and/or suggestions about the equipment or the environment:**
    _____
    _____
    _____
    _____

Main results concerning performance

Total task time and errors:

- Participants were faster but made more errors when there was no avatar
- Translucent avatar was the condition with less errors
- Friedman tests rejected the equality hypothesis -> differences are significant



Main results concerning preference and opinion (median values)
(ordinal data in a Lickert-like scale of 5 levels)

Question (scale)	No avatar	Real. avatar	Trans. avatar
Q1- Preference (number of 1st)	18	9	25
(number of 2nd)	16	25	18
(number of 3rd)	18	18	9
Q2- The task was (1 difficult … 5 easy) to perform	3.5	3	4
Q3-I felt like I was able to interact with the tablet the way I wanted to (1 Strongly Disagree… 5 Strongly Agree)	3	3	3
Q4- I felt as if the hand avatar moved just like I wanted it to (1 Strongly Disagree … 5 Strongly Agree)	NA	3	3.5

All differences were statistically significant (ordinal data -> Friedman test)

Conclusions of the study

The results of our study suggest that:

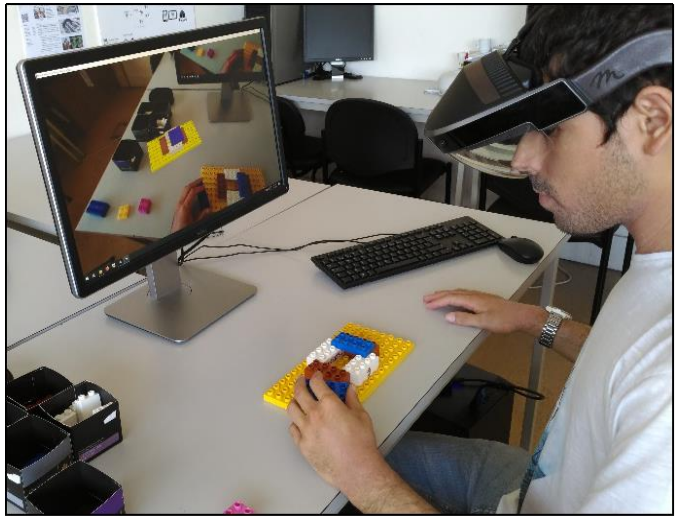
- An avatar may increase usability
- It does not need to be very realistic
  (in line with previous work regarding avatars in immersive VEs)
- The hands-representation provides feedback; however:
  - it may occlude the virtual screen,
  - and become distracting as a consequence of tracking inaccuracies
- The translucent avatar provides feedback not occluding
- Accurate tracking is crucial

Future work

- Improve tracking
- Continue to explore the influence of the hands avatar, e.g.:
  - with other types of mobile devices,
  - to perform different tasks in VEs,
  - using other non-realistic (e.g. robot or cartoon-like) avatars

II - Comparing AR visualization methods for assembly

- Assembly requires more than ever new ways to improve efficiency
- AR has been used to enhance environments and influence UX
- AR-based methods can support users in assembly procedures
- More user studies are needed



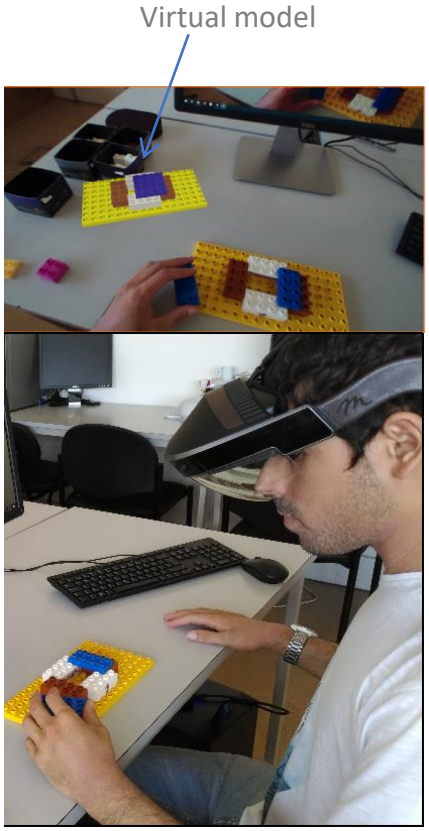
João Bernardo Alves, Bernardo Marques, Carlos Ferreira, Paulo Dias, Beatriz Sousa Santos, "Comparing Augmented Reality visualization methods for assembly procedures", *Virtual Reality*, June, 2021

https://link.springer.com/article/10.1007/s10055-021-00557-8

Comparing AR visualization methods for assembly

- Evaluate three different **AR-based methods**
  - mobile AR,
  - indirect AR,
  - see-through HMD

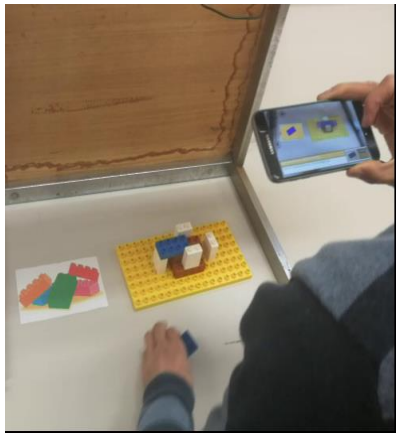
- **User study/controlled experiment** to assess
  - performance,
  - mental/physical workload,
  - preferences



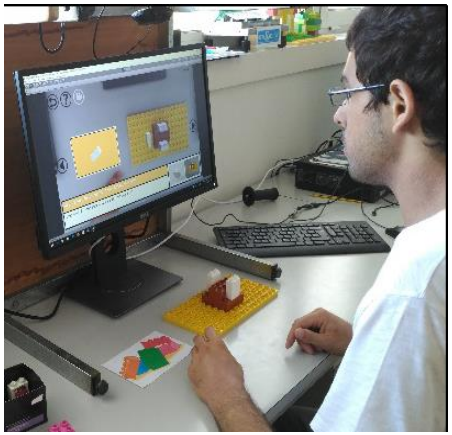
Comparing AR visualization methods for assembly

- **H_0 = all methods lead to similar user performance and acceptance**

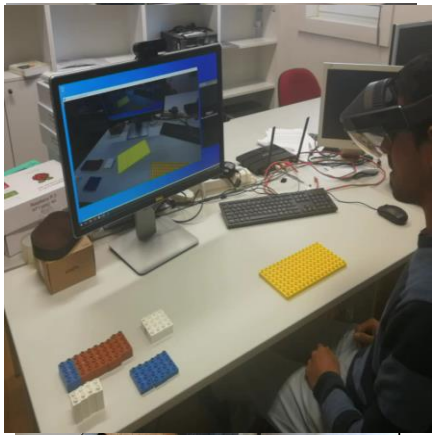
Three experimental conditions (independent/input variables):



Mobile



Indirect



HMD

Comparing AR visualization methods for assembly

- **Experimental design**: **Within Groups** (condition order **randomized**)

- **Dependent (output) variables**:
  - Performance (times and types of errors)
  - mental/physical workload
  - Preferences/opinion

- **Secondary variables**:
  - order in using the conditions
  - demographic data
  - previous experience with AR and assembly

Comparing AR visualization methods for assembly

- **Tasks:**

Assembly of 18 Lego blocks

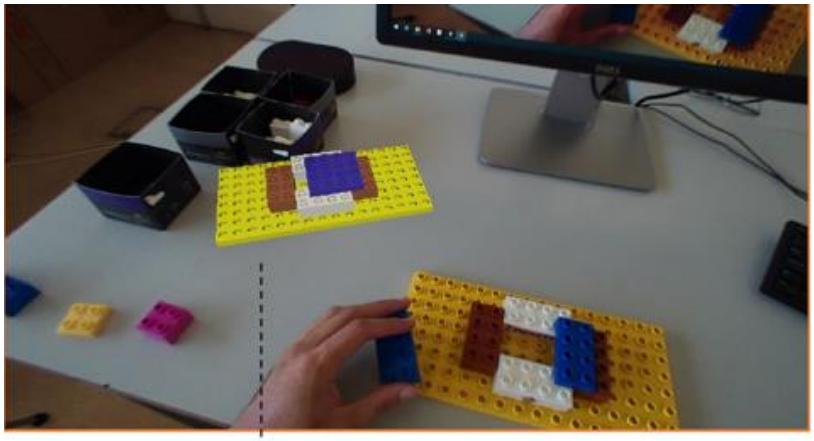
in 18 step-by step 3D instructions

- **Analysis:**

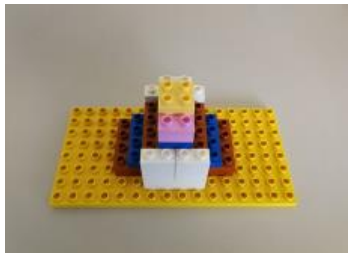
EDA, non-parametric tests

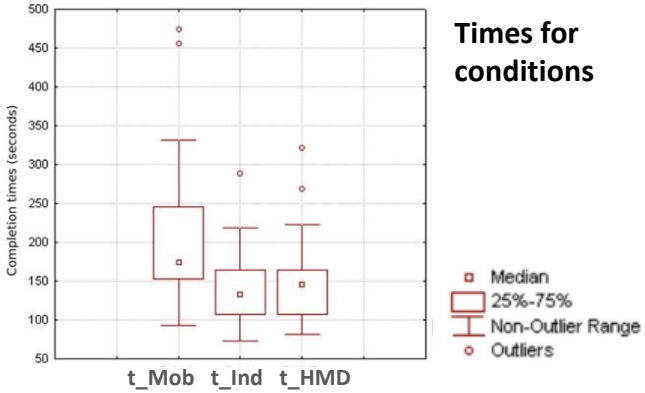
multivariate analysis

- **Thirty participants**



Virtual model





Times for conditions

Types of errors for conditions

Condition	Errors		
	E_Color	E_Location	E_shape
Mob	0	9	15
Ind	0	1	7
HMD	3	16	3

- Main results
  - all methods may support users
  - no “best method” concerning performance and preferences
  - insights on the strengths and weaknesses of each method
  - suggesting guidelines for specific use cases

Comparing AR visualization methods for assembly

- Future work
  - Improve the methods to overcome technical limitations
  - Further study with more:
    - complex tasks to better differentiate among methods
    - realistic settings (noise, illumination, movement, …)