

Influence of crowd's realism and density on human behavior in Virtual Reality

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What do we want to do?

- Accidents happen in crowds causing injuries and deaths
- We want to study crowds and human behaviors to understand these accidents
- ... and determine or evaluate ways to prevent them



Hellfest

Who is involved?

- Laboratoire Central de la Préfecture de Police (LCPP - Paris)
 - Study fire and safety
 - Interested by crowds due to the increase of the number of events
 - The key point is to evaluate the safety of individuals composing a crowd
 - For example during evacuation or intervention of emergency teams



- Inria (VirtUs - Rennes)
 - The general objective is to simulate interactive populated and immersive scenes
 - For this, they study human behavior
 - And translate behaviors into virtual content
 - Crowd simulation, animation, etc.



Studying Human behavior in VR.

	Real	Virtual
Number of participants	Around 80	Around 30, 1 at a time
Cost	High	Low
Installation	Long	Fast
Data acquisition	Difficult	Easy
Ethic	May be dangerous	Safe

Is it pertinent to use VR to study behaviors?

Many studies show and characterize the bias human have when using VR compared to reality.

- Quantitatively different, but qualitatively the same !
- For example, people:
 - Walk slower in VR
 - Tend to be farther from obstacle
 - Walk the same path
 - Look at the same area
 - Do more head movements in VR

But can we use denser crowds in VR?



Objectives of the experiment

- We study human behavior in virtual crowds
- We target static crowds
 - Simplicity of the use case
 - Avoid many bias
- We want to determine:
 - If realistic characters are necessary
 - The limit for the density of static crowd in VR



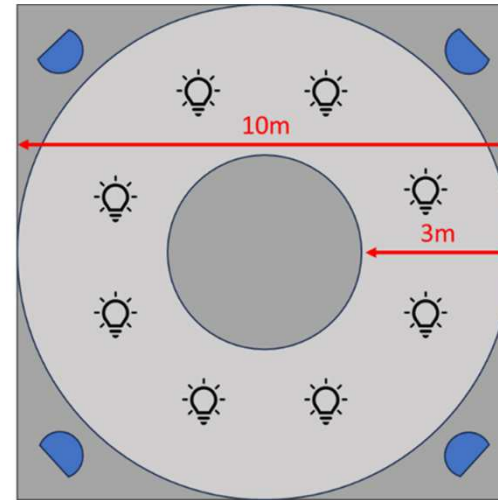
Passenger waiting for departure/arrival



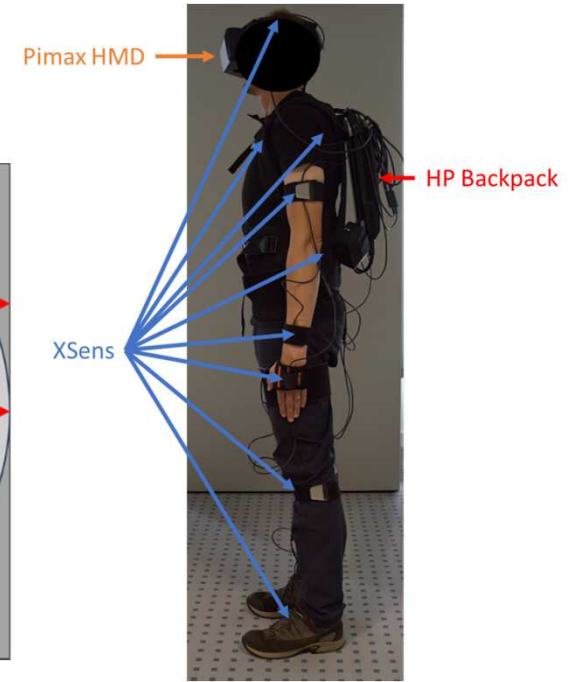
Setup



10mx10m room for the experiment



Room top view



Equipped Participant



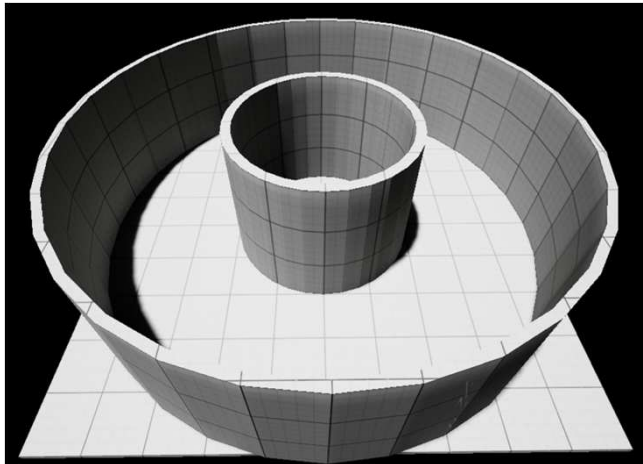
Acquired data

- Some personal information for statistics about our population
 - Age, gender, experience in video games and Virtual Reality
- All other data are virtual:
 - Position, orientation in the Virtual scene of the HMD
 - Body motion through motion capture
 - We record the movement for future analysis
 - But it is also used for embodiment

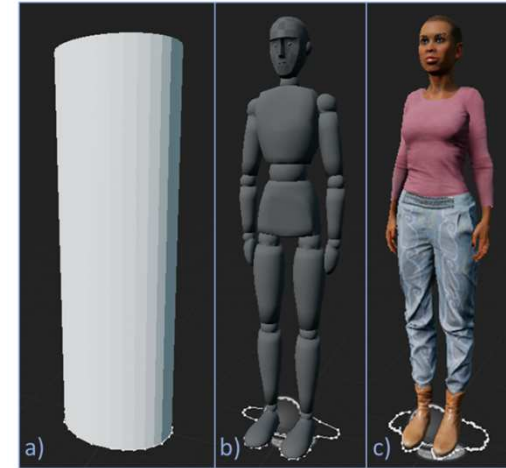


Design of the experiment

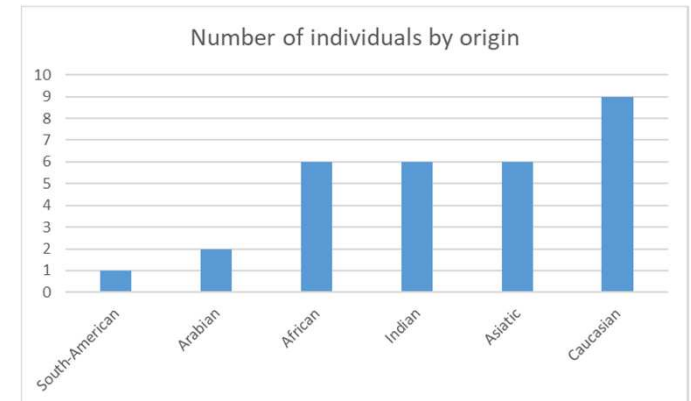
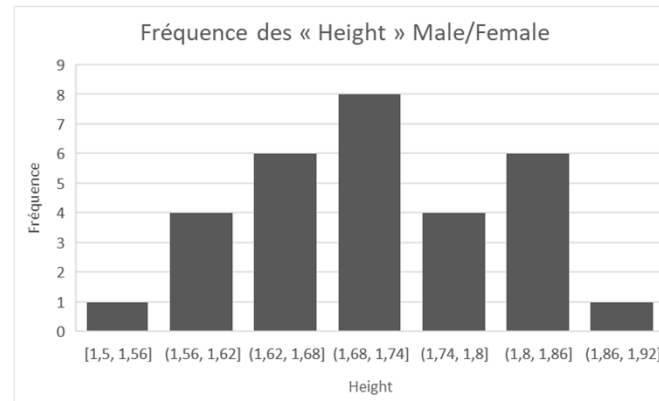
- Walk clockwise while avoiding obstacles
- Circular corridor for continuous walking
- Each semi-circle corresponds to a « scenario »



Virtual Circular room

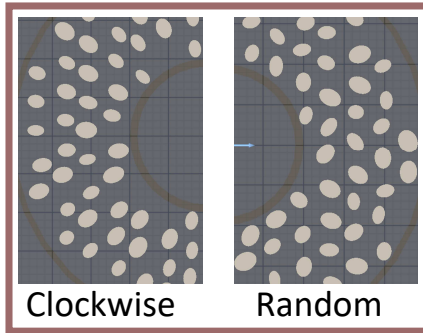


Exemple of obstacles



Scenarios

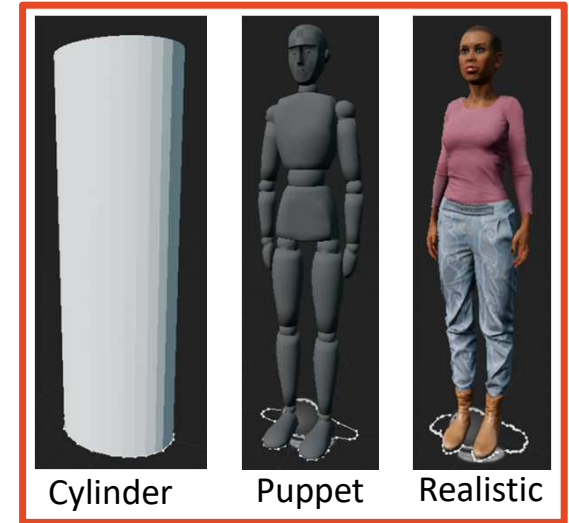
DENSITY
0,5p/m ²
0,75p/m ²
1,0p/m ²
1,25p/m ²
1,5p/m ²
1,75p/m ²
2,0p/m ²



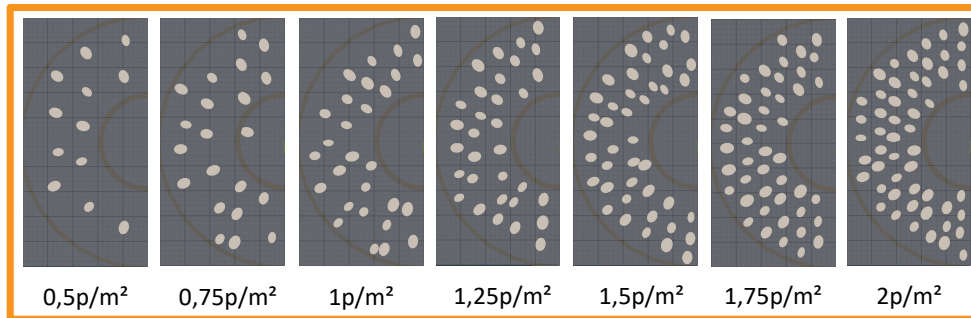
ORIENTATION
CLOCKWISE
RANDOM



3D MODEL
CYLINDER
PUPPET
CHARACTER CREATOR

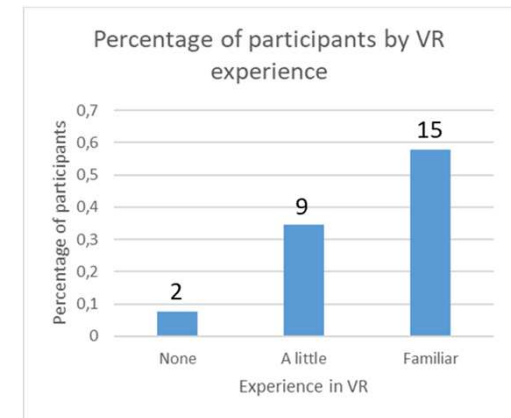
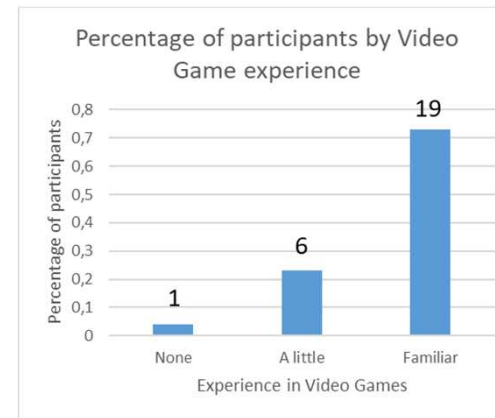
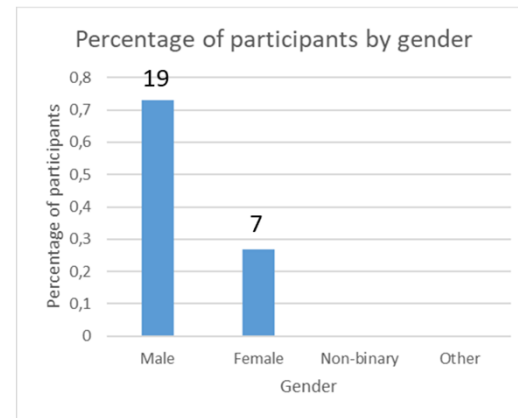
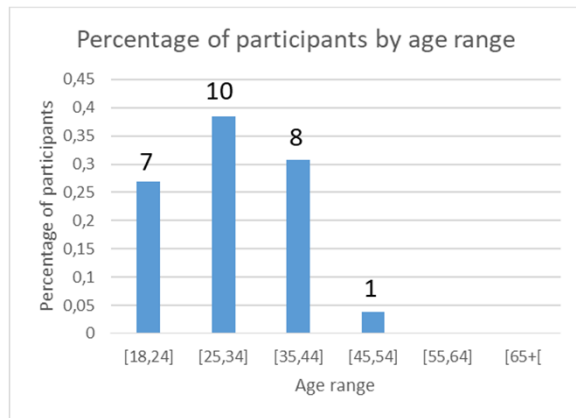


= 42 scenarios



Participants

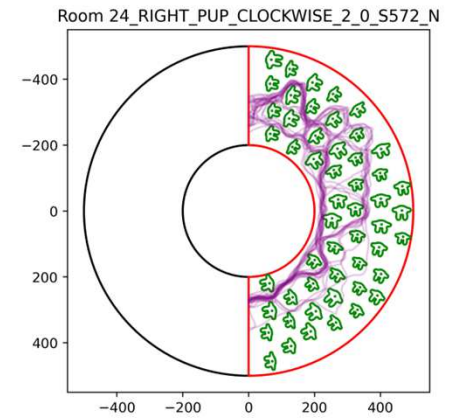
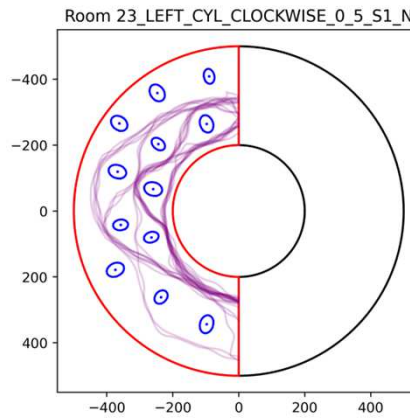
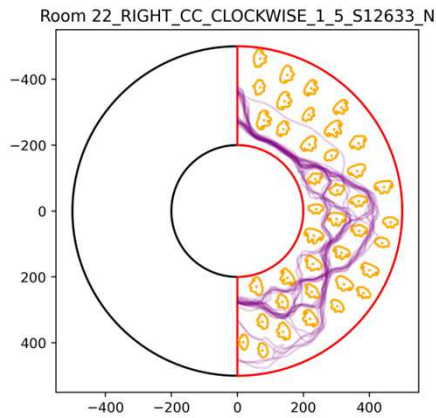
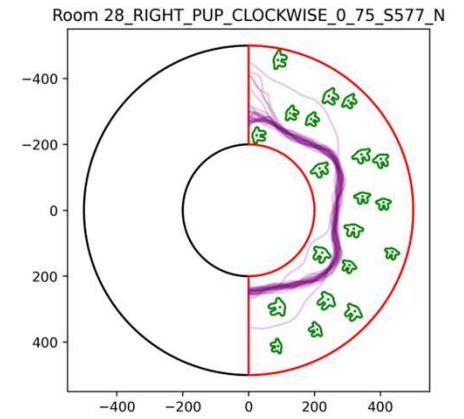
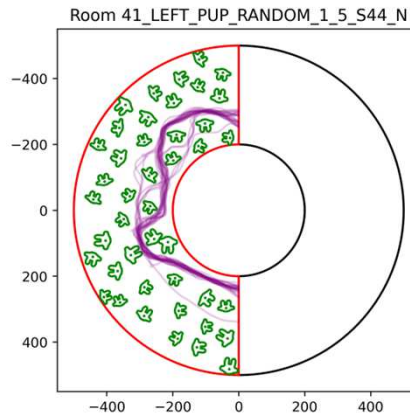
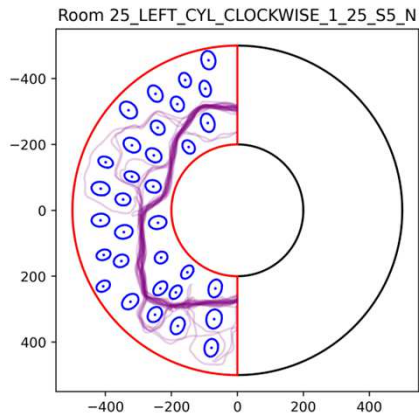
- 26 peoples participated in this experiment.
- 25 finished it.



Video: Participant walking in 2 p/m²



Trajectories



Calculating density

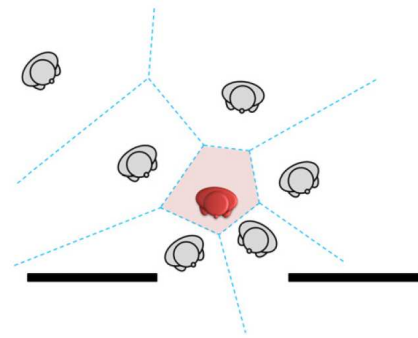
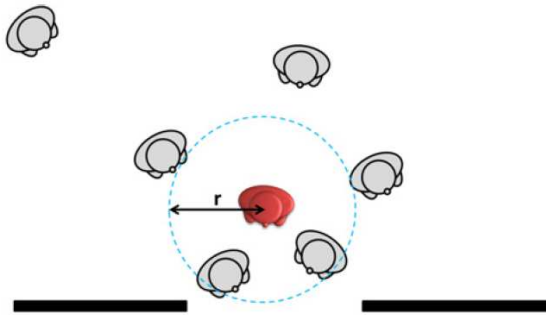


Fig. 4. Visualization of the Range-based density measure.

Fig. 5. Voronoi-graph based density calculation method.

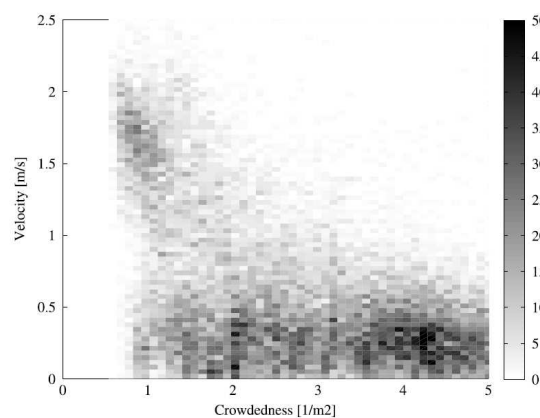
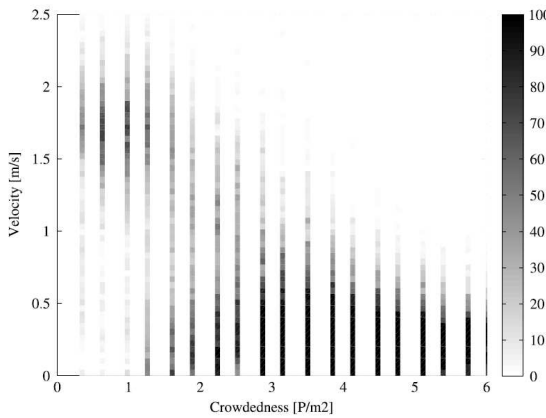
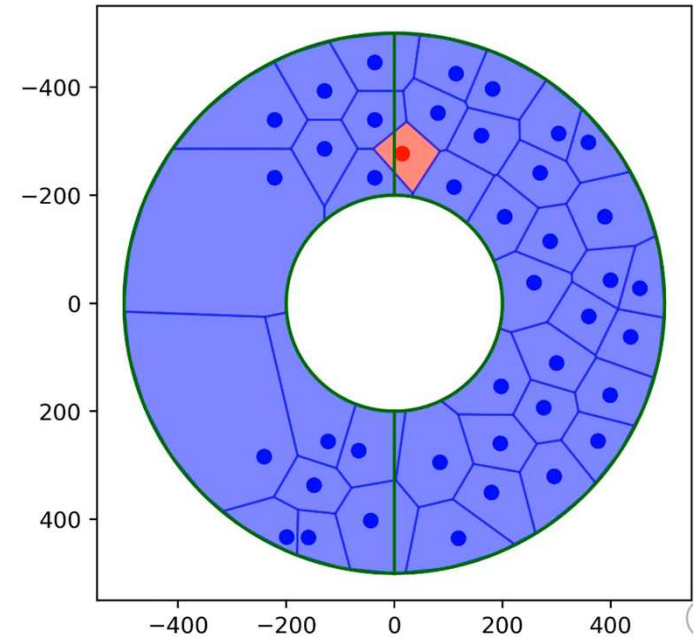


Fig. 16. Results of RB measure—frequency plot of the fundamental diagram.

Fig. 17. Results of VD measure—frequency plot of the fundamental diagram.



Voronoi for 1/2 in our experiment

Quantification of the level of crowdedness for pedestrian Movements, Duives et al. (2015)



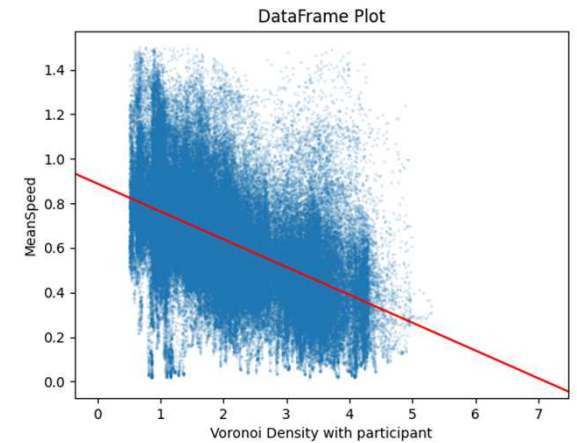
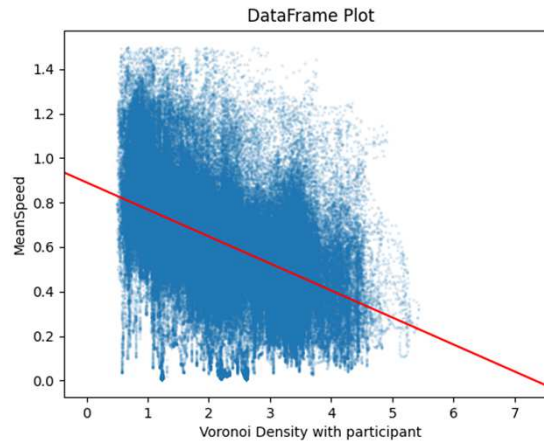
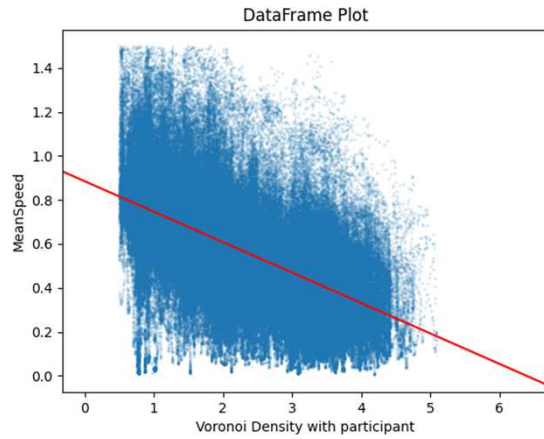
Fundamental Diagrams

Cylinder

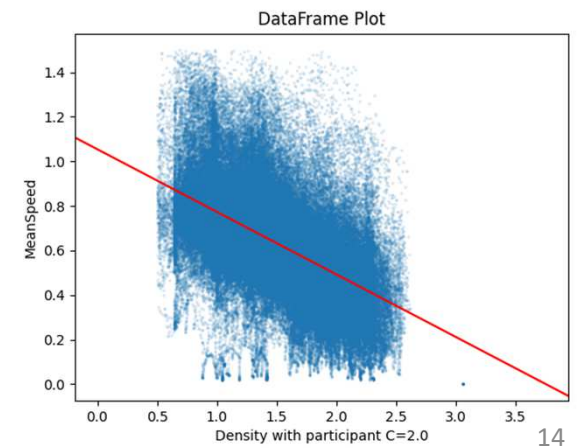
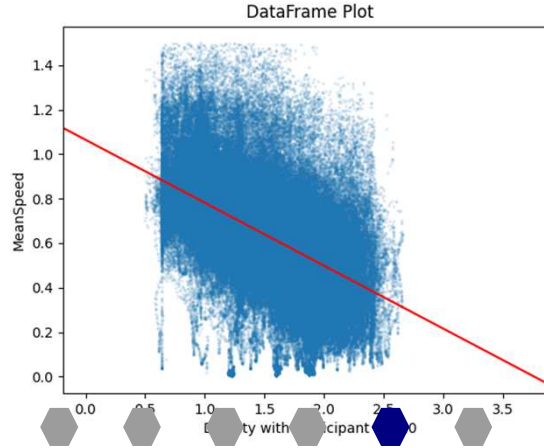
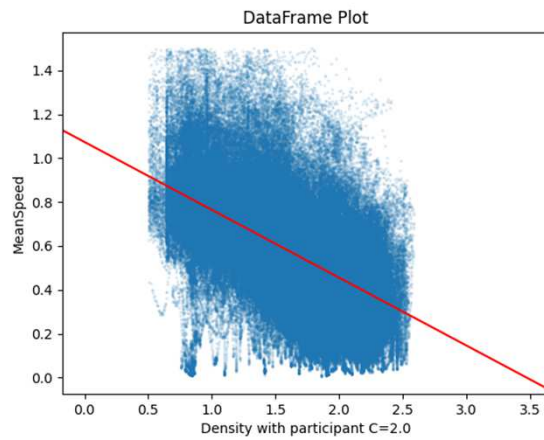
Puppet

CharacterCreator

Voronoi



Circle



Statistical tests

- We did some statistical test to comprehend the different distribution and know if there are significant differences on the linear regression:
 - ANOVA: Test if the distribution comes from the same population
 - There are no significant differences between the obstacles.
 - This means the obtained fundamental diagram have globally the same distribution.
 - T-Test: Estimates the differences between the mean
 - In Puppets and Realistic scenarios, there is no detectable differences.
 - In Cylinder and the other two scenarios, there are detectable differences.
 - Wilcoxon-Mann-Whitney: Two groups of data are close or not
 - Same results as T-Test
 - Participants participants doesn't exactly behave the same way around an anthropomorphic figure and an object figure in VR.
 - They seem to behave the same way whether the anthropomorphic figure is realistic or not.



Conclusion

- There doesn't seem to have a walkable density limitation in VR.
- The fundamental diagram (relation speed/density) is correct no matter what type of obstacle we use
- Participants didn't behave exactly the same way with anthropomorphic obstacles and cylinder
- There doesn't seem to have significant differences between anthropomorphic obstacles
- This tend to prove that we can simplify the rendering of the crowd without changing the participant behavior, as long as it remains anthropomorphic.



Contexte

Experiment

Results

Conclusion

Next

- This experience collected lots of data and can have many use such as:
 - Trajectory prediction
 - Obstacle avoidance
 - Animation
- The data will be publicly available



Contexte

Experiment

Results

Conclusion

Questions

