In-depth analysis of VR.net VR motion sickness dataset

Motivation and Grand vision

- VR.net dataset is the first of its kind and aims to standardize datasets used for studying motion sickness in VR environments.
- Our grand vision is to explore a machine-learning approach using DL or CNN to predict motion sickness based on various factors whose information the dataset provides.
- Currently, the ML approaches for predicting VR motion sickness rely primarily on data collected from user studies that the authors conducted.
- However, since the dataset is very new, we decided to pursue ML-based approaches only after thoroughly evaluating the data provided by the dataset. Hence, our goal for the next few weeks is to thoroughly investigate patterns, analyze data, and identify potential issues in the dataset.

MVP

Our objective is to conduct an *in-depth analysis* of the VR motion sickness dataset and *juxtapose our findings with existing user studies.* This comparative approach aims to validate our results, identify discrepancies with prior studies, and potentially uncover dataset issues or vice versa.

As part of the MVP, we have the following work completed:

- Thoroughly understood all the data provided by the dataset
- Identified issues in the dataset
- Analyzed and developed visualizations for:
    - General trend analysis for motion sickness over time for all games
    - Analysis of light intensity and motion sickness
    - Analysis of headset movement and motion sickness scores
    - Analysis of object density and motion sickness scores
    - Analysis of camera movement and motion sickness scores

Issues in dataset

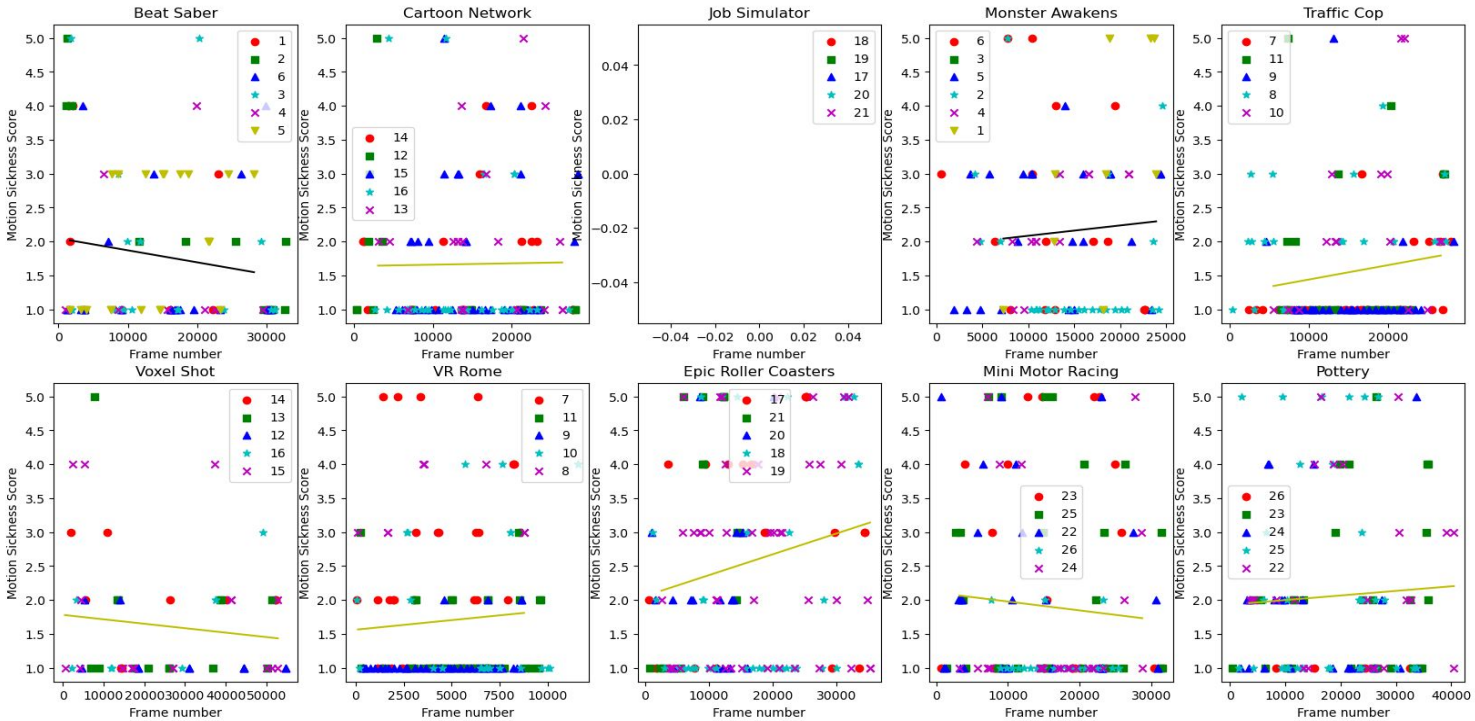
- All the data for the ‘Job Simulator’ game is missing. Ideally, there should have been a folder for each playing session containing the 5 csv files for that session. While the motion sickness scores for 5 participants playing this game is included, the rest of the data is missing
- Light related data for all participants playing ‘Voxel Shot VR’ is missing. Light.csv for all the 5 participants is empty
- Object.csv for the ‘Monster Awakens’ game has commas within the ‘name’ column value. This would give errors while using pandas to read data. The column values were modified from “CFXM4_Space Thruster C (Blue-Purple, CFX Blend)” to “CFXM4_Space Thruster C (Blue-Purple CFX Blend)” and from “CFX4 Smoke Trail A (Curved, Black)_F4D(Clone)” to “CFX4 Smoke Trail A (Curved Black)_F4D(Clone)”

Number of participants	36
Number of games	10
Number of playing sessions	62
CSV files included for each game	5 camera.csv object.csv light.csv control.csv pose.csv
Motion sickness score data	Contains total 62 FMS (Fast Motion Sickness scale) ratings containing self-reported motion sickness ratings from participants from a scale of 1-5 (1 being lowest and 5 being highest)

Summary of MVP

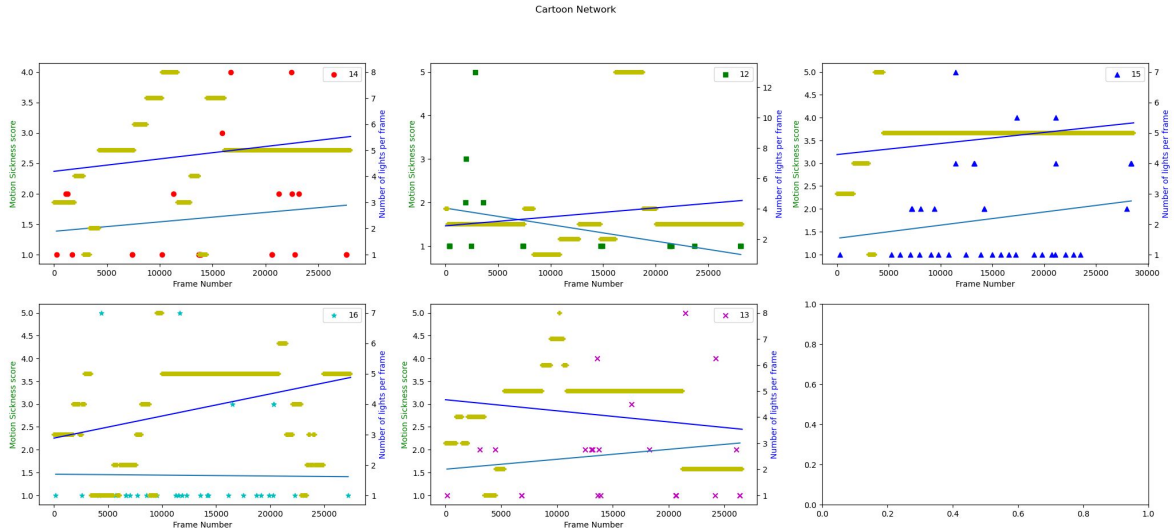
Problem analyzed	Details	Relevant Research	Summary of results
Motion sickness over time	This was a basic analysis of the motion sickness scores over time for all the games	-	6 / 9 games showed an increase of motion sickness over time.
Number of light per frame and motion sickness	This was an attempt to check whether the density of lights in the VR environment affects motion sickness	-	Increasing density of lights over time also had motion sickness scores increasing over time. A possible reasoning could be that once motion sickness sets in, an increasing density of lights can produce more visual stimuli, making it difficult for the brain to accurately interpret the surroundings.
Object density and motion sickness	This was an attempt to check whether the density of objects in the VR environment affects motion sickness	-	No correlation was found. The results were pretty random
Headset rotational movement and motion sickness	Computed correlations between angular velocity for headset and motion sickness scores.	https://dl.acm.org/doi/abs/10.1145/3409118.3475137	Voxel VR game in particular had greater correlations between angular-y and motion sickness scores. The relevant research paper indicates a possible explanation as to why rotational movements across y-axis can cause more motion sickness.
Camera rotation vs. motion sickness	We computed a correlation matrix between user-submitted sickness scores for the game Beat Saber versus camera and pose data.		Correlation matrix shows a strong correlation between **camera rotation about the z-axis** and high sickness scores for Beat Saber.

Motion Sickness over time

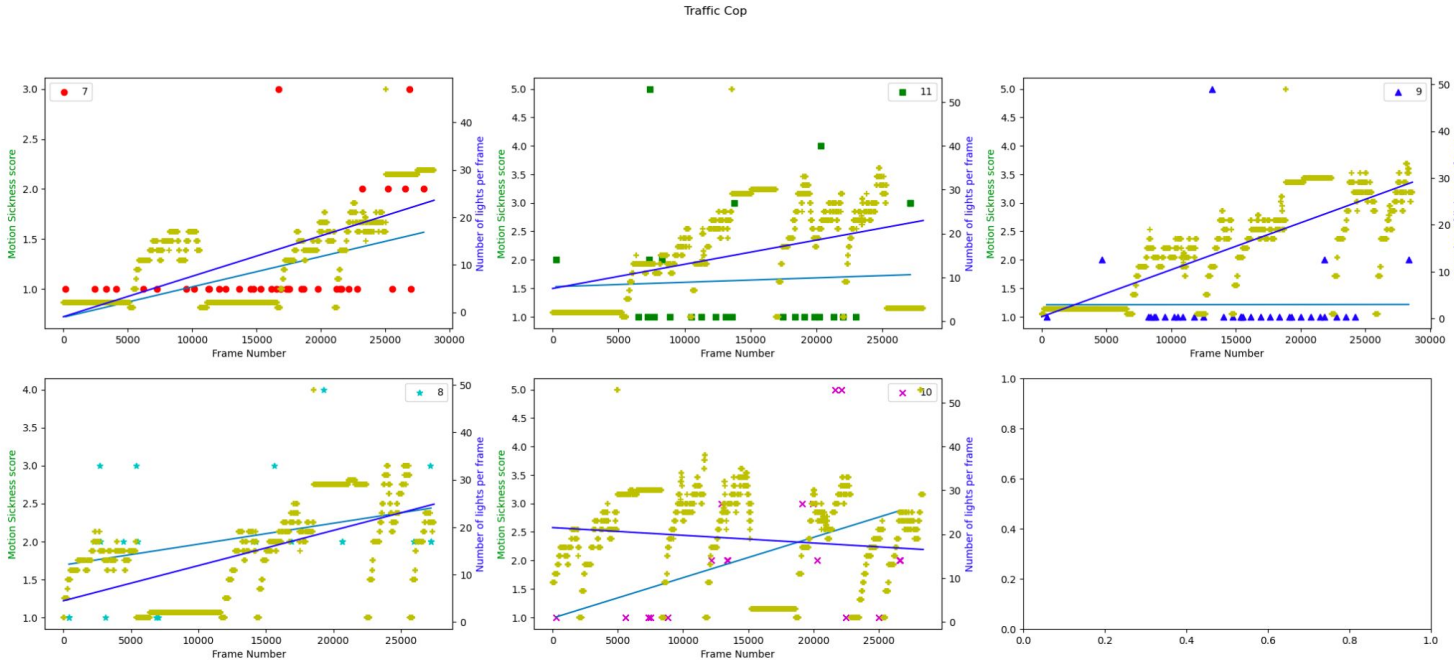


Light density and motion sickness

- Results are only included for 2 games which had considerable changes in the light density over the game period. While ‘Voxel Shot VR’ did not have any light related data at all, the rest of the games had a constant light density => it was a flat curve which didn’t make sense to be analyzed.
- What do the results mean?
  For the games that had a significant change in light density, almost all cases had the motion sickness scores increasing too.

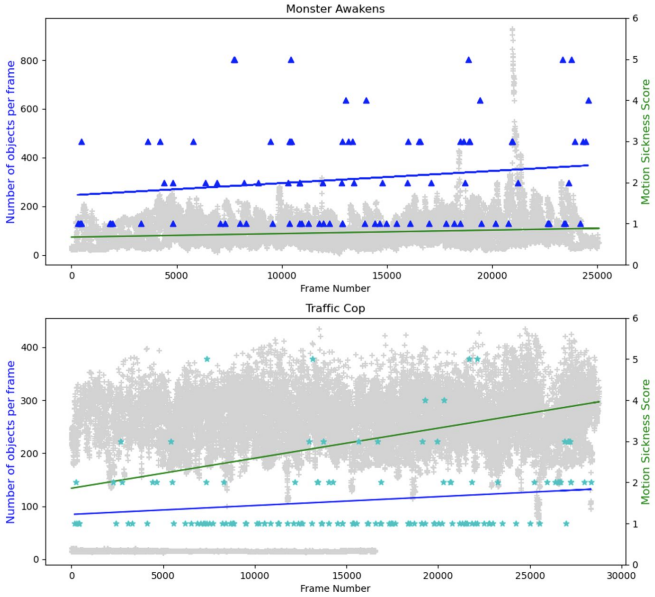


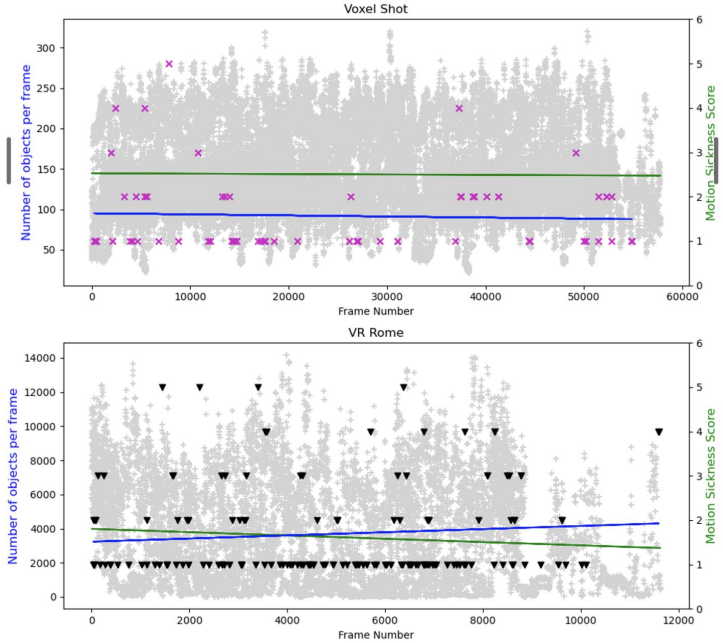
Light density and motion sickness



Object density and motion sickness

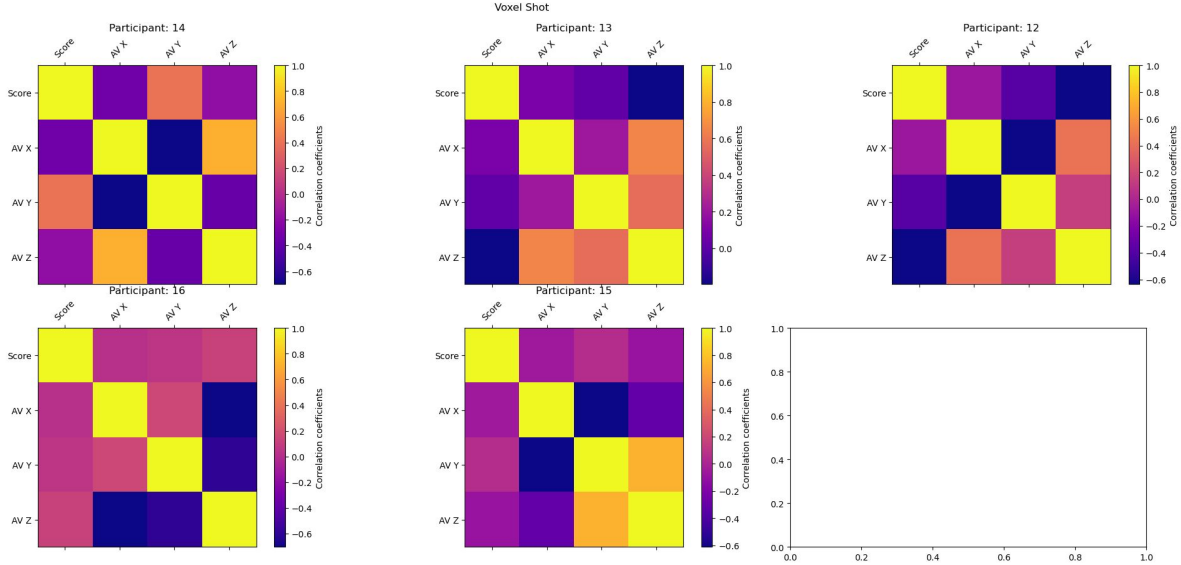
- What do the results mean?
  The plots did not yield any patterns at all. This was mostly because the object density data was too dense and very few motion sickness scores when compared to the object data.





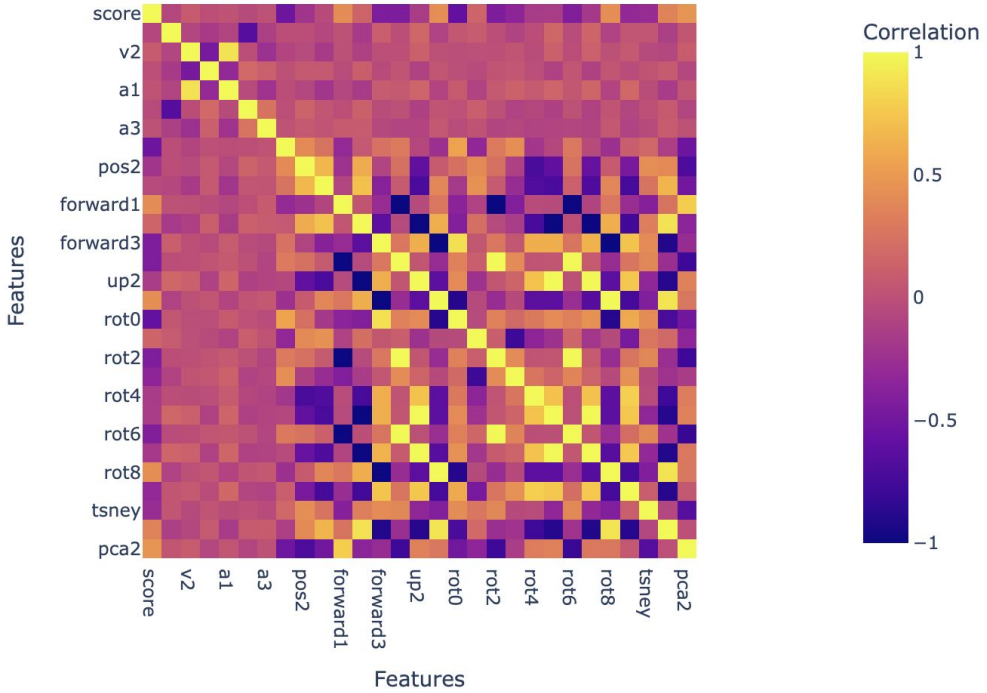
Headset rotational movement and motion sickness

- How was this plotted?
  Extracted the frame number corresponding to each motion sickness score. For this frame number, angular velocity was extracted from pose.csv and the correlation was computed
- What do the results mean?
  One interesting result observed was the angular-y velocity and motion sickness score was consistently higher than angular-x velocity and motion sickness score for ‘Voxel VR game’ which basically involves shooting zombies. This game in particular involves more headset movement than the others and it seemed like changes in angular-y components had more correlation with the sickness scores. While correlation is not an accurate measure, the result makes sense since angular-y velocity is known to cause greater motion sickness than rotational movements across x-axis.



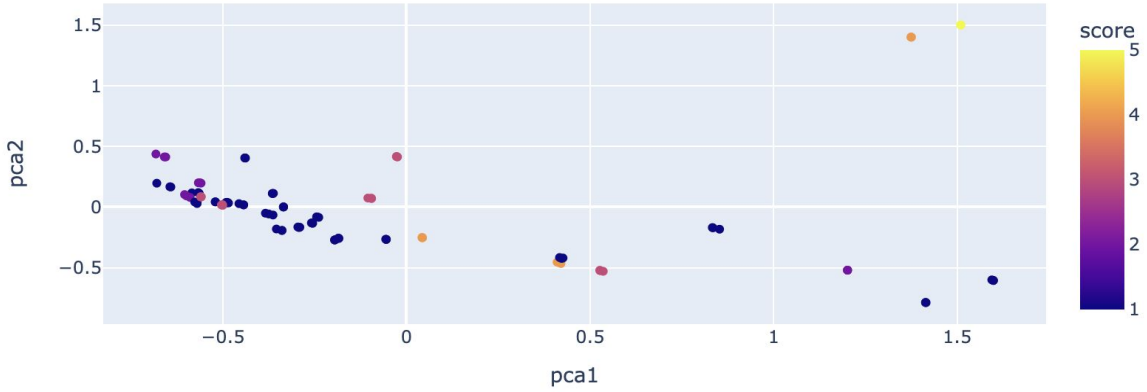
Pose + camera data workflow

- Projection matrix tells us:
  - FOV + aspect ratio
  - Near and far clipping planes
- View matrix tells us camera **position** + **orientation** in 3D space
- We also have **velocity** + **angular velocity** of in-scene camera

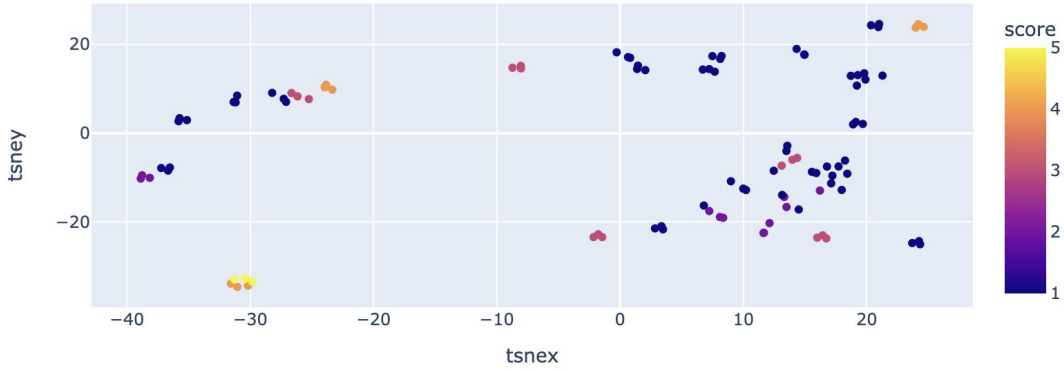


- Motion sickness correlates (+) with **forward1**, **up3**, and **rot8**
  - **rot8** is *in-game camera rotation about the z-axis*

PCA



t-SNE



Results

- Motion sickness correlates (+) with **forward1**, **up3**, and **rot8**
  - **rot8** is *in-game camera rotation about the z-axis*
- PCA is not effective at visualizing this problem
  - t-SNE is better, but is hard to interpret

Future work

As part of the future work, we will be analyzing more data in the dataset and possibly find more correlations. Few areas we are interested in include:

- Does motion sickness increase with when the camera is moving vs if it's standing still?
- Does motion sickness increase with excessive camera accelerations or decelerations?
- Does restricting FOV reduce motion sickness?

- Compare across games, not just Beat Saber
    - Does **z-axis rotation** correlate with motion sickness across games?

- Compare with existing literature

- Incorporate time series modeling

- Incorporate scene images (?)

Thanks for listening! Questions?