Habitable Layout Design driven by Psychophysical Criteria using Virtual Reality

UNC CHARLOTTE

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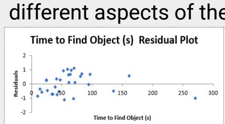
unity

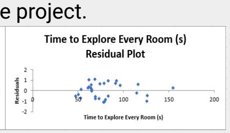
Project Description

The UNCC_HABIT project consists of evaluating 10 conceptual layout designs. The designs were optimized using matlab and given to the team for evaluation. The goal was to produce a virtual reality environment that allowed users to access the various layout designs. The implementation of the 3D models into the VR environment was to be used to collect data of the human interaction with the layout designs and run a statistical analysis.

Conclusion

The UNCC_HABIT team could not find a significant regression model based on the data collected. The best model used Layers as the dependent variable and only explained 26.6% of variation around the mean. By looking at the residuals plots below, it shows that the data collected is not a good candidate for regression. However, other data analytical models could better show relationships between the different aspects of the project.



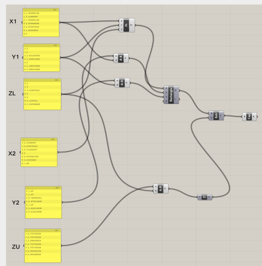


For Future Research

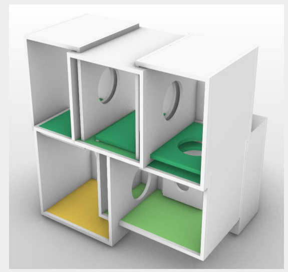
If the project was going to continue, there are a few recommendations to consider:

- Define more variables for data collection such as, number of entrance/exit holes, etc.
- Explore variable transformations within the variables (i.e. log).
- Use other methods than regression to reveal relationships such as, factorial design.

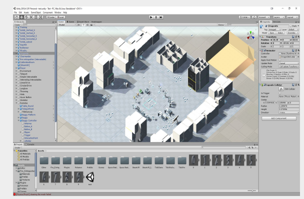
Process Breakdown



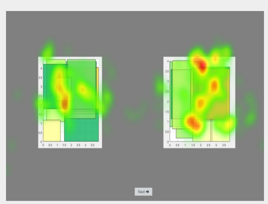
The Grasshopper script uses the **vertices of each module** to generate an unbaked **Rhino model.** The Rhino model is then baked and edited.



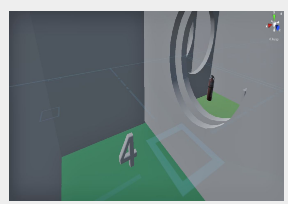
After editing with holes for entry and exit from each room, the **model is viewed in VR.** All 10 models are converted and edited.



The models are then **imported into the Unity VR environment.** Landing spots and objects are added to the environment to ensure proper accessibility and for data collection purposes.



Using iMotions eye tracking devices, **heat maps of fixation points** were recorded for each model. Complete fixation point data was then extracted from the study.



Users were tasked to **find a specified object** and **explore every room** of each model. Time taken to complete both tasks was recorded and a **situational awareness question** was asked afterwards.

	Waste(m)	total print time (hrs)	Layers	Time to Find Object (s)	Time to Explore Every Room (s)	Situational awareness element
	11.09	40.32	1	13.81	50.37	0
	11.09	40.32	1	34	73.3	0
Solid Cuboid	11.09	40.32	1	9.83	79.93	1
	26.67	45.88	3	161.56	64.36	0
	26.67	45.88	3	270.55	125.98	1
solidz_vertical_4	26.67	45.88	3	69.82	68.36	0
	9.24	39.5	1	54.07	77.91	1
	9.24	39.5	1	42.1	69.19	0
solid_horizontal_4	9.24	39.5	1	45.23	47.2	0
	27.07	47.73	3	52.49	92.11	0
	27.07	47.73	3	24.45	154.44	1
solid vertical_5	27.07	47.73	3	61.04	116.24	0
	26.13	40.85	2	61.94	53.13	1
	26.13	40.85	2	25.92	126.35	1
solid horizontal_5	26.13	40.85	2	39.17	114.83	0
	23.29	44.53	2	71.57	65.17	0
	23.29	44.53	2	135.5	83.04	0
Overz_cuboid	23.29	44.53	2	47.23	64.09	0
	9.28	39.92	1	35.19	52.67	1
	9.28	39.92	1	69.74	79.33	0
Overz_horizontal_4	9.28	39.92	1	17	69.1	0
	14.26	41.73	2	41.04	61.72	0
	14.26	41.73	2	94.66	65.13	0
Overz_horizontal_5	14.26	41.73	2	24.32	60.99	1
	23.27	40.82	3	82.8	78.73	1
	23.27	40.82	3	64.22	91.26	1
Overz_vertical_4	23.27	40.82	3	59.52	62.12	1
	96.86	74.14	3	96.86	74.14	1
	80.75	96.34	3	80.75	96.34	1
overz_vertical5	65.62	83.26	3	65.62	83.26	0

The data collected from 3D printing and the Unity VR environment was broken down by model and then analyzed.

Data Collection & Analysis

FlashForge Creator Pro 3D Printer

3 variables were used to collect data from the 3D printer, which were print time, amount of waste, and number of layers in the model. Estimated print time and amount of material used was given by loading each model into the 3D printing software.

iMotions Eye Tracker

In an attempt to determine model preferences, a slideshow with two models on each slide was played for the user while tracking their eye movements.

Unity Virtual Reality Environment

The tasks that users had to complete were done in random order to decrease any possible learning effect. The situational awareness question was used to determine if the user paid attention to aspects of the model outside of their given task.

Analysis

The eye tracking and VR data were separately paired with the 3D printing data in Excel. Multiple regressions were run in an attempt to show correlations between the different aspects of the project. The best models are shown below.

Regression Statistics	
Multiple R	0.584999429
R Square	0.342224332
Adjusted R Square	0.26632714
Standard Error	0.723664721
Observations	30

ANOVA

	df	SS	MS	F	Significance F
Regression	3	7.084043674	2.361347891	4.50905127	0.01124883
Residual	26	13.61595633	0.523690628		
Total	29	20.7			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.730344578	0.452682325	1.613371095	0.118737124	-0.200157267	1.660846422
Time to Find Object (s)	0.006349925	0.002664981	2.382728004	0.024782622	0.000871978	0.011827873
Time to Explore Every Room	0.010927683	0.005558302	1.966010821	0.060060602	-0.000497572	0.022352937
Situational awareness	0.189195159	0.275547549	0.686615285	0.49840367	-0.37720094	0.755591258

Regression Statistics	
Multiple R	0.489927757
R Square	0.240029207
Adjusted R Square	0.176698307
Standard Error	753.131707
Observations	40

ANOVA

	df	SS	MS	F	Significance F
Regression	3	6449284.748	2149761.583	3.790080496	0.01845049
Residual	36	20419465.25	567207.3681		
Total	39	26868750			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	7305.909212	2051.611649	3.561058554	0.001061108	3145.047934	11466.77049
Waste	48.10703468	34.96865811	1.375718637	0.177408364	-22.81269106	119.0267604
Print_Time	-176.3920571	54.88342188	-3.213940586	0.002761515	-287.7007957	-65.08331841
Layers	31.08556112	238.6474421	0.130257257	0.897088037	-452.9138845	515.0850067