FAMU/FSU College of Engineering

Department of Electrical and Computer Engineering

Concept Selection

Team 315

Control Module/Interface for Service Robots

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House of Quality Chart

Requirements / Needs		Response Time	Safe to Move	Weight	Cost
		-	+	-	-
1) Follow User	+	↑		↑	
2) Mode Switching	+	↑			
3) Modular	+	↑		↑	↑
4) Inexpensive	-			↑	↑
5) Safety	+	↓	↑		↓
Targets		< 0.5 seconds	Path Clear	< 10 lbs	< $65

Figure 1: House of Quality table

AHP Charts

Scale of Importance: 1=equal, 3=moderate, 5=strong, 7=very strong, 9=extreme

Power Source

Power Source						
	Safety	Efficiency	Cost	Lifetime	Mean = $^{n}\text{sqrt}(\pi\, a_i)$	Weights
Safety	1	2	5	2	2.115	0.45
Efficiency	1/2	1	3	1	1.066	0.228
Cost	1/5	1/3	1	1/3	0.386	0.082
Lifetime	1/2	1	3	1	1.066	0.228

Figure 2: We have rated safety as the most important measure with our control module with efficiency and lifetime being close seconds for how we'd like our system given it will be put to work throughout the day. Cost was rated last in this case but it is convenient that our safest option is the cheapest as well so it would remain our top choice.

Power Source					
	Weight	Lead Acid Battery	Solar Lithium-Ion Power	Nuclear Power	Fuel Cell
Safety	0.45	.40	.30	.15	.15
Efficiency	0.228	.15	.20	.30	.30
Cost	0.082	.60	.10	.15	.15
Lifetime	0.228	.10	.25	.25	.30
Score		$\sum_{i=1}^{4} w_i a_{i1} = .29$	$\sum_{i=1}^{4} w_i a_{i2} = .23$	$\sum_{i=1}^{4} w_i a_{i3} = .19$	$\sum_{i=1}^{4} w_i a_{i4} = .20$

Figure 3: With safety being our most important measure, the lead acid battery is most safe as it is still meant to be used with caution but does not require certain safety measure that must be taken with the others. The other fuel options are much more efficient and have longer lifespans but their cost and safety scores weigh them lower.

Camera/Sensors

	Visual Acuity	Cost	Processing Power	Power Consumption	Availability	Mean	Weights
Visual Acuity	1	5	5	7	3	3.49	0.51
Cost	1/5	1	7	1/3	9	1.33	0.19
Processing Power	1/5	1/7	1	3	1/5	0.44	0.06
Power Consumption	1/7	3	1/3	1	1/5	0.49	0.07
Availability	1/3	1/9	5	5	1	0.98	0.14

Figure 4: Camera/Sensor Criteria weighting table

Visual Acuity was rated highest as the ability to monitor a wide area with good precision was the most important. Cost was second as our project has a limited budget and our implementation would not be considered by customers if it is too expensive. Processing power and power consumption were rated low as most feasible options would require low power and processing power. Availability was rated third in the sense of how easy it was to get a hold of, it loses out to cost as must cheap parts are in high availability.

		Lidar	Digital Camera	Radar	Acoustic Sensors	WIFI Sensing	Laser Based Sensors	Ultrasonic Sensors	Photoelectric Sensors
Visual Acuity	0.51	0.05							0.143
	0.18								0.055
									0.1
	0.11								0.091
									0.50
		0.134							

Figure 5: Camera/Sensor alternatives selection table

Digital Camera has the highest score with 0.1711. Digital cameras are extremely easy to come by, have very affordable and cheap options, and give a high amount of visual acuity.

User Interface

	Ease of Use	Comfortability	Cost	Mean	Weights
Ease of Use	1	3	7	2.756	0.67
Comfortability	1/3	1	3	1	0.24
Cost	1/7	1/3	1	0.362	0.09

Figure 6: User Interface Criteria weighting table

Ease of use was rated the highest among the criteria included. This is because our design must be easy for a user to understand and begin using compared to cost and comfort. Comfortability was second since ease of use is prioritized ahead, but the design must be comfortable to ensure that it will be used. Cost ranked last since ease of use and comfort are vital to ensuring that the design is utilized.

	Weights	Touchscreen	Voice	Mobile App	Push Buttons	Keyboard
Ease of Use	0.67	0.65	0.07	0.72	0.1	0.34
Comfortability	0.24	0.23	0.22	0.23	0.2	0.15

Cost	0.09	0.12	0.71	0.05	0.7	0.51
Score		0.5	0.16	0.54	0.18	0.31

Figure 7: User Interface alternatives selection table

The mobile application had the highest score of 0.54 where it was deemed the easiest to use compared to all the other alternatives. The touchscreen was ranked second with a score of 0.5, and this alternative could be used as a second option. The keyboard ranked third due to its moderate difficulty of use and worse comfort in comparison to a touchscreen or mobile app. Push buttons were fourth due to its benefit in use and comfort but is cost effective. Voice came last although it is easy to use and vary comfortable compared to push buttons and keyboard.

Robot's Display:

Criteria Weighting

	Ease of Use	**Comfortability**	**Cost**	**Battery Usage**	**Mean**	**Weights**
Ease of Use	1	1	1/5	1/3	.57	.11
Comfortability	1	1	1/5	1/3	.57	.11
Cost	5	5	1	5/3	2.54	.49
Battery Usage	3	3	3/5	1	1.52	.29

Figure 8

The cost of the display was weighted the highest followed by battery usage. This is because all of the methods to interface the cart are relatively straightforward, so keeping the cost and power consumption down is more important. No one would use the cart if it was too expensive for companies to buy or didn't have a large enough battery capacity to maintain power for a reasonable amount of time.

Rating the Alternatives

	LCD	LED Screen	Phone	Tablet	Computer Monitor	LEDs	HUD
Ease of Use	.8	.8	.7	.75	.9	.4	.2
Comfortability	.9	.9	1	.9	.1	.8	.05
Cost	.3	.3	1	.1	.01	.95	.3
Battery Usage	.2	.2	.9	.2	.1	.95	.2

Figure 9

The alternatives for the robot's display are rated based on how viable they are for each category.

Scoring

	weights	LCD	LED Screen	Phone	Tablet	Computer Monitor	LEDs	HUD
Ease of Use	.11	.8	.8	.7	.75	.9	.4	.2
Comfort ability	.11	.9	.9	1	.9	.1	.8	.05
Cost	.49	.3	.3	1	.1	.01	.95	.3
Battery Usage	.29	.2	.3	.9	.2	.1	.95	.2
Score = $\Sigma a_i * w_i$		.392	.421	.938	.289	.144	.873	.232

Figure 10

The display interfaced through the phone had the highest score which was calculated by summing all of the products of the rating for the category multiplied by its respective weight. The phone is already going to be used to interface the robot through the app. Therefore, there is no additional cost, the power consumption for a Bluetooth receiver should be minimal and people should be comfortable using their phones. The LED had the second highest score because they are lower power and very cheap to implement into the design.

Connectivity

	Connection Accuracy	**Feasibility**	**Cost**	**Mean**	**Weights**
Connection Accuracy	1	7	3	2.75	0.69
Feasibility	1/7	1	1	0.522	0.13
Cost	1/3	1	1	0.693	0.18

Figure 11: Criteria Weights

The most important factors for connectivity are connection accuracy, feasibility, and cost. A large emphasis is placed on connection accuracy, while taking into account how feasible the idea is and what the cost will be.

	Weight	**Bluetooth**	**Wi-Fi**	**Wired Ethernet**	**USB**	**Wireless Ethernet**	**GPS**
Connection Accuracy	0.69	0.18	0.18	0.24	0.20	0.10	0.10
Feasibility	0.13	0.25	0.20	0.00	0.25	0.20	0.10
Cost	0.18	0.22	0.22	0.10	0.22	0.19	0.05
Score		0.20	0.19	0.18	0.21	0.13	0.091

Figure 12: Decision Matrix

The options are compared above. For connection accuracy, wired Ethernet would have the best accuracy; however, it is not feasible. GPS is not a viable option considering it would not be that accurate and it would be costly. Wireless Ethernet would not have the best connection accuracy. USB, Wi-Fi, and Bluetooth are viable options and all three may be used.

Pugh Charts

Power Source

Power Source					
	Weight	Lead Acid Battery	Solar Lithium Ion Battery	Nuclear	Fuel Cell
Safety	5	-	-1	-1	-1
Cost	3	-	-1	-1	-1
Lifetime	2	-	+1	+1	+1
Efficiency	4	-	+1	+1	+1
Score			-1	-1	-1
Continue?		Yes	No	No	No

Figure 13: All other three sources are more efficient and have longer lifespans but the risk of injury with maintenance and total cost with installation would use up all our budget or even more than that. The Lead acid battery remains the top choice as it is the most budget friendly while still providing the output needed to run the robot

User Interface

	Weight	**Touchscreen (Reference)**	**Voice**	**Mobile App**	**Push Buttons**	**Keyboard**
Ease of Use	5	-	-4	3	3	-1
Comfortability	4	-	4	3	3	-1
Cost	3	-	2	4	2	1
Score			2	39	33	-6
Continue?		No	No	Yes	No	No

Figure 14 Selection Matrix

Connectivity

	Weight	Bluetooth (Reference)	Wi-Fi	Wired Ethernet	USB	Wireless Ethernet	GPS (Cameras/Sensors)
Accuracy	5	-	0	+1	+1	0	+1
Feasibility	3	-	-1	-1	-1	+1	0
Cost	3	-	0	0	0	-1	-1
Score			-3	2	2	3	2
Continue?		Yes	No	No	No	Yes	No

Figure 15: Selection Matrix

Camera/sensors

		Digital Camera (reference)	Lidar	Radar	Acoustic Sensors	WIFI Sensing	Laser Based Sensors	Ultrasonic Sensors	Photelectric sensors
Visual Acuity	5	-	-1	0	0	0	0	0	0
Cost	3	-	+1	+1	+1	-1	-1	-1	-1
Processing Power	2	-	-1	-1	-1	+1	+1	+1	+1
Power Consumption	4	-	+1	+1	+1	+1	-1	-1	-1
Availability	1	-	+1	+1	+1	+1	-1	-1	-1
Score			1	6	6	4	-6	-6	-6
Continue?		Yes	Yes	Yes	Yes	Yes	No	No	No

Figure 16

Digital Camera was placed as reference as it was the winner of the AHP chart, lidar radar and acoustic sensors still hold some potential and can be returned to if digital camera turns out to be an insufficient alternative.

Display

		LCD	LED Screen	Phone	Tablet	Computer Monitor	LEDs	HUD
Ease of Use	1	+1	+1	+1	+1	+1	+1	+1
Comfort	1	+1	+1	+1	+1	+1	+1	-1
Cost	5	-1	-1	+1	-1	-1	+1	-1
Battery Usage	3	-1	-1	+1	-1	-1	+1	-1
Score		-6	-6	10	2	-6	10	-9
Continue?		No	No	Yes	Yes	No	Yes	No

Figure 17:

The phone and LED interfaces were rated the highest because of their low cost, lower power consumption and ease of use. These two categories got perfect score because of this. The tablet also got a passing score while the rest failed because they all are expensive and power demanding options.

Final Selection

Digital Camera was chosen as it has some of the best visual acuity as well as cost options as seen in figure 6. Lidar, radar and acoustic sensors can still be considered as close alternatives.

The lead acid battery is our most budget friendly option, while also being our safest which remains as our priority for this project.

The mobile application was selected as the best option for the user interface since it is easy to use, comfortable, and cost effective as shown in the AHP and Pugh charts. This selection ranked first for ease of use which was weighted the most important compared to comfortability and cost.

Bluetooth was chosen as the victor for connectivity based off the AHP and Pugh Charts. It provides solid connection accuracy while being feasible and cost-effective.

The phone was scored the highest for the interface in both the Pugh charts and the AHP. This is because using the phone doesn’t add any additional cost to the system or draw any power from the battery besides the Bluetooth receiver already required to switch between modes. Additionally, it is convenient and comfortable for people to just use their phones. The LEDs score the second highest for the same reasons, but don’t provide the same level of interactivity and feedback.