Concept Selection

T522: Nicolas Garcia, Madison Jaffe, David Alicea, Ethan Saffer

Mechanical Engineering, FAMU-FSU College of Engineering

EML4551C: Senior Design I

Dr. Shayne McConomy

November 6, 2020

There are many techniques that can be used to narrow down the multitude of concepts generated by our design team. The techniques include the creation of an Importance Weight Factor through Binary Comparison Chart, followed by a House of Quality, two Pugh Charts, and lastly the Analytical Hierarchy Process to determine the final concept selected. These work well as a set, as the Binary Comparison lets the engineers know how important each costumer need is, which can then be used to find how important each engineering characteristic is during the House of Quality. The importance weight factor generated by the Binary Comparison was the team's first task, as that determines what aspects of the design are most important. Once the Importance Weight Factor was made, the team can perform analysis of the engineering characteristics using the House of Quality. This in turn lets the team know the importance of each function in terms of the customer needs while avoiding as much bias as possible. Once that was determined, the Pugh Charts allowed the group to compare their top eight ideas made during concept generation. It should be noted that selecting ideas directly does introduce a certain amount of bias to the analysis; however, these ideas were chosen by the four team members for their feasibility and usability. These ideas were then compared to a current market solution for the same issue the team is addressing.

House of Quality

The House of Quality is a crucial step in the design process, as it allows the team to understand the weight of each engineering concept in relation to their costumer needs without skewing the data on relative notions. In the top row, the team's engineering concepts, and their units are listed, while in the first column the customer requirements and their weight factors are listed. These are then ranted on a basis of 0,1,3,5,7,9 depending on importance. Even numbers are not allowed as these are often "safety" numbers which lead to less defined results. The House of

Quality can be seen below in Table 3. From this table you can see that our most important customer requirement was being able to recognize surrounding areas followed by being intuitive with O & M training and notifying emergency contacts. Our engineering concepts that ranked the highest in this table were interpreting sensory information, alert of information, and alert of a physical object. Out of a raw score of 629 they scored 122, 101, and 97, respectively. After this analysis, these will be the concepts the team will be most focused on.

Table 1: House of Quality

		Engineering Concepts							
Units		Inches	Latitude/Longitude	Seconds	Seconds	Minutes	GB	Seconds	Seconds
Customer Requirements	Importance Weight Factor	Alert of Elevation	Determine Location	Interpret Sensory Information	Access Emergency Contact	Interface With Pre-Existing Skills	Store Frequent Tasks	Alert of Physical Object	Inform User of Possible Threats
1. Helps Avoid Ground Irregularities	2	9	5	9	-	7	1	7	9
2. Allows for Location Awareness	2	9	9	9	-	1	1	7	3
3. Recognizes Surrounding Objects	6	7	7	9	-	3	5	9	3
4. Notify Emergency Contacts	3	1	5	-	9	1	3	1	1
5. Intuitive with O & M Training	4	5	5	5	3	9	3	3	1
6. Identifies and Reads Text	2	-	-	5	1	-	5	-	-
7. Priced for low-income households	3	-	-	-	-	-	-	-	-
Raw Score (629)	N/A	**101**	**85**	**122**	**41**	**73**	**65**	**97**	**43**
Relative Weight %		**16.1**	**13.5**	**19.4**	**6.5**	**11.6**	**10.3**	**15.4**	**6.8**
Rank Order		**2**	**4**	**1**	**8**	**5**	**6**	**3**	**7**

From the House of Quality, the crucial engineering concept was the ability to “Interpret Sensory Information.” This characteristic obtained the highest raw score and highest relative weight, which did not surprise the group as the primary goal of the design was enhancing the ability for a person who is visually impaired to navigate with no adverse consequences. In terms of importance, “Alert of Elevation” and “Alert of Physical Object” were the next most important characteristics, since “Alert of Elevation” ensures the user does not trip over treacherous terrain, and “Alert of Physical Object” ensures they do not hit an object while in motion. These three are crucial for a person walking around attempting to decipher what is around them.

Table 2: Pugh Chart 1

Engineering Characteristics	Orcam MyEye2	Concepts							
		Sensor Pin Chip	Pin Matrix Haptics	Sensor Watch	GPS App	GPS Watch	Haptic Smart Cane	Smart Glasses	Audio Feedback Cane
Alert of Elevation	Datum	+	+	+	-	-	+	S	+
Determine Location		S	S	+	+	+	+	+	+
Interpret Sensory Information		-	-	-	-	+	S	-	S
Access Emergency Contact		S	S	S	+	-	+	-	+
Interface With Pre-Existing Skills		S	+	+	S	S	+	S	S
Store Frequent Tasks		+	S	S	S	-	S	-	+
Alert of Physical Object		+	+	+	-	+	-	+	-
Inform User of Possible Threats		+	+	+	+	+	-	+	+
# of Pluses		4	4	5	3	4	4	3	5
# of Minuses		2	1	1	3	3	2	3	1

The Pugh chart is a method of comparing designs directly to each other based on how well they fulfill our designated engineering concepts. The chart also uses a datum to compare each potential product to and score against. This process is conducted by lining up our potential designs and using a system of pluses and minuses to score each idea. A plus means that the product would outperform the datum and a minus means an idea would underperform compared to the datum. An "S'' means that a potential design matches up with the datum evenly in terms of fulfilling the need of an engineering concept. In our original Pugh chart, the 3 high-fidelity design ideas and the 5 medium fidelity design ideas were all compared to an existing product on the market, the OrCam MyEye2. The team selected the top 6 design ideas from the original Pugh chart to compare to a new datum. This Pugh Chart can be seen in Table 3.

Table 3: Pugh Chart 2

Engineering Characteristics	GPS Watch	Concepts					
		Sensor Pin Chip	Sensor Watch	GPS App	Haptic Smart Cane	Smart Glasses	Audio Feedback Cane
Alert of Elevation	Datum	+	+	S	+	S	+
Determine Location		-	-	S	-	S	-
Interpret Sensory Information		+	+	S	+	+	+
Access Emergency Contact		S	S	+	S	S	-
Interface With Pre-Existing Skills		S	+	+	+	S	+
Store Frequent Tasks		+	S	S	S	S	S
Alert of Physical Object		+	+	-	+	+	+
Inform User of Possible Threats		+	+	-	+	+	+
# of Pluses		5	5	2	5	3	5
# of Minuses		1	1	2	1	0	2

That new datum was selected from the original eight designs from the first Pugh chart. In this case, the GPS (global position) watch was selected as the datum in the second Pugh chart. At the end of this process, the sensor pin chip, sensor watch, and the haptic smart cane were all chosen to move on to further selection.

Analytical Hierarchy Process

Table 4: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}								
Criteria Comparison Matrix [C]								
	Alert of Elevation	Determine Location	Interpret Sensory Information	Acccess Emergency Contact	Interface With Pre-Existing Skills	Store Fequent tasks	Alert of Physical Objects	Inform User of Possible Threats
Alert of Elevation	1.00	1.00	0.33	5.00	1.00	3.00	0.33	1.00
Determine Location	1.00	1.00	0.33	5.00	1.00	3.00	1.00	1.00
Interpret Sensory Inform	3.00	3.00	1.00	5.00	3.00	5.00	1.00	1.00
Access Emergency Conta	0.20	0.20	0.20	1.00	0.20	1.00	0.33	0.20
Interface With Pre-	1.00	1.00	0.33	5.00	1.00	3.00	0.33	1.00
Store Frequent Tasks	0.33	0.33	0.20	1.00	0.33	1.00	0.33	0.33
Alert of Physical Object	3.00	1.00	1.00	3.00	3.00	3.00	1.00	1.00
Inform User of Possible	1.00	1.00	1.00	5.00	1.00	3.00	1.00	1.00
Sum	10.53	8.53	4.40	30.00	10.53	22.00	5.33	6.53

Table 5: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}									
Criteria Comparison Matrix [C]									
	Alert of Elevation	Determine Location	Interpret Sensory Information	Acccess Emergency Contact	Interface With Pre-Existing Skills	Store Fequent tasks	Alert of Physical Objects	Inform User of Possible Threats	Criteria Weights{W}
Alert of Elevation	0.09	0.12	0.08	0.17	0.09	0.14	0.06	0.15	0.11
Determine Location	0.09	0.12	0.08	0.17	0.09	0.14	0.19	0.15	0.13
Interpret Sensory Inform	0.28	0.35	0.23	0.17	0.28	0.23	0.19	0.15	0.24
Access Emergency Conta	0.02	0.02	0.05	0.03	0.02	0.05	0.06	0.03	0.03
Interface With Pre-	0.09	0.12	0.08	0.17	0.09	0.14	0.06	0.15	0.11
Store Frequent Tasks	0.03	0.04	0.05	0.03	0.03	0.05	0.06	0.05	0.04
Alert of Physical Object	0.28	0.12	0.23	0.10	0.28	0.14	0.19	0.15	0.19
Inform User of Possible	0.09	0.12	0.23	0.17	0.09	0.14	0.19	0.15	0.15
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

The Analytical Hierarchy Process is a method of evaluating and selecting a final design concept in a mathematical way. The first step of this process is developing a rating scale for our pairwise comparison and giving each engineering concept a weight. This is then normalized and analyzed for possible bias, and once it is determined to be no major bias, the team may proceed. Once each engineering characteristic has its respective weight and no bias, the high-fidelity concepts are further compared to them. In doing so, the best concept can be determined.

The team started the process by creating a criteria comparison matrix which evaluates the value of the engineering concepts our design will include. That matrix is then normalized so that each column of rankings has a sum of 1.00. We then found the values of the weighted sum vector and the consistency vector which were then used to conduct a consistency check. From this check we found values for the average consistency, consistency index, consistency ratio, and RI value. If the consistency ratio is less than 0.10 then the analysis was determined to be unbiased. After doing this process for each engineering concepts together, we then reiterated this process for each engineering concept by itself versus our 3 high-fidelity design ideas. The Analytical Hierarchy Process showed that the haptic smart cane is the best design based on this evaluation.

Final Selection

To finalize the selection process, the team did the Final Rating Matrix to determine as objectively as possible which concept was the most fit for the project in terms of the engineering characteristics. This is referenced in Table 8, where a percentage score was given to each concept in terms of each engineering characteristic.

Table 6: Final Rating Matrix

	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Alert of Elevation	0.11	0.11	0.78
Determine Location	0.16	0.19	0.66
Interpret Sensory Information	0.45	0.45	0.09
Access Emergency Contact	0.20	0.20	0.60
Interface With Pre-Existing	0.14	0.14	0.71
Store Frequent Tasks	0.33	0.33	0.33
Alert of Physical Object	0.43	0.14	0.43
Inform User of Possible Threats	0.33	0.33	0.33

Once the Final Rating Matrix was created, each one of the concepts had their overall score in each characteristic aggregated and turned into a percentage to display the most effective concept. Table 7 displays the percentage of success between the three possible concepts. As such, the chosen concept should be the one with the highest Alternative Value.

Table 7: Alternative Value Matrix

Concept	Alternative Value
Sensor Pin Chip	0.27
Sensor Watch	0.24
Haptic Smart Cane	0.49

This concept was the Haptic Smart Cane, which consists of an attachment to the standard white cane for the visually impaired. This device would also work with voice-recognition if possible and include a camera (ideally the camera from the user's smartphone) faced upward near the handle of the shaft which can detect objects and relay the information to the user view haptic sensations such as vibrations. An alteration to this idea is relaying these items as audio; however, this is not ideal as it would interfere with the user's hearing of any external noises.

Appendix A

Table A-1: Binary Comparison Chart

Interprted Customer Needs	1	2	3	4	5	6	7	Total 1
1. Helps Avoid Ground Irregulari	-	1	0	0	0	0	1	2
2. Allows for Location	0	-	0	1	0	1	0	2
3. Recognizes Surrounding	1	1	-	1	1	1	1	6
4. Notify Emergency Contact	1	0	0	-	1	0	1	3
5. Intuitive with O & M Train	1	1	0	0	-	1	1	4
6. Identifies and Reads Text	1	0	0	1	0	-	0	2
7. Priced for low-income households	0	1	0	1	0	1	-	3
Total:	4	4	0	4	2	4	4	6

Table A-2: House of Quality

		Engineering Concepts							
Units		Inches	Latitude/Longitude	Seconds	Seconds	Minutes	GB	Seconds	Seconds
Customer Requirements	Importance Weight Factor	Alert of Elevation	Determine Location	Interpret Sensory Information	Access Emergency Contact	Interface With Pre-Existing Skills	Store Frequent Tasks	Alert of Physical Object	Inform User of Possible Threats
1. Helps Avoid Ground Irregularities	2	9	5	9	-	7	1	7	9
2. Allows for Location Awareness	2	9	9	9	-	1	1	7	3
3. Recognizes Surrounding Objects	6	7	7	9	-	3	5	9	3
4. Notify Emergency Contacts	3	1	5	-	9	1	3	1	1
5. Intuitive with O & M Training	4	5	5	5	3	9	3	3	1
6. Identifies and Reads Text	2	-	-	5	1	-	5	-	-
7. Priced for low-income households	3	-	-	-	-	-	-	-	-
Raw Score (629)		**101**	**85**	**122**	**41**	**73**	**65**	**97**	**43**
Relative Weight %	N/A	**16.1**	**13.5**	**19.4**	**6.5**	**11.6**	**10.3**	**15.4**	**6.8**
Rank Order		**2**	**4**	**1**	**8**	**5**	**6**	**3**	**7**

Table A-3: Pugh Chart 1

Engineering Characteristics	Orcam MyEye2	Concepts							
		Sensor Pin Chip	Pin Matrix Haptics	Sensor Watch	GPS App	GPS Watch	Haptic Smart Cane	Smart Glasses	Audio Feedback Cane
Alert of Elevation	Datum	+	+	+	-	-	+	S	+
Determine Location		S	S	+	+	+	+	+	+
Interpret Sensory Information		-	-	-	-	+	S	-	S
Access Emergency Contact		S	S	S	+	-	+	-	+
Interface With Pre-Existing Skills		S	+	+	S	S	+	S	S
Store Frequent Tasks		+	S	S	S	-	S	-	+
Alert of Physical Object		+	+	+	-	+	-	+	-
Inform User of Possible Threats		+	+	+	+	+	-	+	+
# of Pluses		4	4	5	3	4	4	3	5
# of Minuses		2	1	1	3	3	2	3	1

Table A-4: Pugh Chart 2

Engineering Characteristics	GPS Watch	Concepts					
		Sensor Pin Chip	Sensor Watch	GPS App	Haptic Smart Cane	Smart Glasses	Audio Feedback Cane
Alert of Elevation	Datum	+	+	S	+	S	+
Determine Location		-	-	S	-	S	-
Interpret Sensory Information		+	+	S	+	+	+
Access Emergency Contact		S	S	+	S	S	-
Interface With Pre-Existing Skills		S	+	+	+	S	+
Store Frequent Tasks		+	S	S	S	S	S
Alert of Physical Object		+	+	-	+	+	+
Inform User of Possible Threats		+	+	-	+	+	+
# of Pluses		5	5	2	5	3	5
# of Minuses		1	1	2	1	0	2

Table A-5 : Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}								
Criteria Comparison Matrix [C]								
	Alert of Elevation	Determine Location	Interpret Sensory Information	Acccess Emergency Contact	Interface With Pre-Existing Skills	Store Fequent tasks	Alert of Physical Objects	Inform User of Possible Threats
Alert of Elevation	1.00	1.00	0.33	5.00	1.00	3.00	0.33	1.00
Determine Location	1.00	1.00	0.33	5.00	1.00	3.00	1.00	1.00
Interpret Sensory Inform	3.00	3.00	1.00	5.00	3.00	5.00	1.00	1.00
Access Emergency Conta	0.20	0.20	0.20	1.00	0.20	1.00	0.33	0.20
Interface With Pre-	1.00	1.00	0.33	5.00	1.00	3.00	0.33	1.00
Store Frequent Tasks	0.33	0.33	0.20	1.00	0.33	1.00	0.33	0.33
Alert of Physical Object	3.00	1.00	1.00	3.00	3.00	3.00	1.00	1.00
Inform User of Possible	1.00	1.00	1.00	5.00	1.00	3.00	1.00	1.00
Sum	10.53	8.53	4.40	30.00	10.53	22.00	5.33	6.53

Table A-6: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}									
Criteria Comparison Matrix [C]									
	Alert of Elevation	Determine Location	Interpret Sensory Information	Acccess Emergency Contact	Interface With Pre-Existing Skills	Store Fequent tasks	Alert of Physical Objects	Inform User of Possible Threats	Criteria Weights{W}
Alert of Elevation	0.09	0.12	0.08	0.17	0.09	0.14	0.06	0.15	0.11
Determine Location	0.09	0.12	0.08	0.17	0.09	0.14	0.19	0.15	0.13
Interpret Sensory Inform	0.28	0.35	0.23	0.17	0.28	0.23	0.19	0.15	0.24
Access Emergency Conta	0.02	0.02	0.05	0.03	0.02	0.05	0.06	0.03	0.03
Interface With Pre-	0.09	0.12	0.08	0.17	0.09	0.14	0.06	0.15	0.11
Store Frequent Tasks	0.03	0.04	0.05	0.03	0.03	0.05	0.06	0.05	0.04
Alert of Physical Object	0.28	0.12	0.23	0.10	0.28	0.14	0.19	0.15	0.19
Inform User of Possible	0.09	0.12	0.23	0.17	0.09	0.14	0.19	0.15	0.15
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A-7: Consistency Check

Weighted Sum Vector	Criteria Weights{W}	Consistency vector
0.94	0.11	8.37
1.07	0.13	8.32
2.02	0.24	8.57
0.29	0.03	8.23
0.94	0.11	8.37
0.35	0.04	8.32
1.61	0.19	8.61
1.22	0.15	8.32

Table A-8: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
8.00	1.40	8.39	0.06	0.04

Appendix B

Analytical Hierarchy Charts

Alert of Elevation

Table B-1: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights	Alert of Elevation		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	0.14
Sensor Watch	1.00	1.00	0.14
Haptic Smart Cane	7.00	7.00	1.00
Sum	9.00	9.00	1.29

Table B-2: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor	Haptic Smart Cane	Design Alternative Priorities {Pi}
Sensor Pin Chip	0.11	0.11	0.11	0.11
Sensor Watch	0.11	0.11	0.11	0.11
Haptic Smart Cane	0.78	0.78	0.78	0.78
Sum	1.00	1.00	1.00	1.00

Table B-3: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
0.33	0.11	3.00
0.33	0.11	3.00
2.33	0.78	3.00

Table B-4: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Determine Location

Table B-5: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}	Determine Location		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	0.20
Sensor Watch	1.00	1.00	0.33
Haptic Smart Cane	5.00	3.00	1.00
Sum	7.00	5.00	1.53

Table B-6: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane	Design Alternative Priorities {Pi}
Sensor Pin Chip	0.14	0.20	0.13	0.16
Sensor Watch	0.14	0.20	0.22	0.19
Haptic Smart Cane	0.71	0.60	0.65	0.66
Sum	1.00	1.00	1.00	1.00

Table B-7: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
0.48	0.16	3.01
0.56	0.19	3.01
2.00	0.66	3.06

Table B-8: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.03	0.01	0.03

Interpret Sensory Info

Table B-9: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}	Interpret Sensory Information		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	5.00
Sensor Watch	1.00	1.00	5.00
Haptic Smart Cane	0.20	0.20	1.00
Sum	2.20	2.20	11.00

Table B-10: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor	Haptic Smart Cane	Design Alternative Priorities {Pi}
Sensor Pin Chip	0.45	0.45	0.45	0.45
Sensor Watch	0.45	0.45	0.45	0.45
Haptic Smart Cane	0.09	0.09	0.09	0.09
Sum	1.00	1.00	1.00	1.00

Table B-11: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
1.36	0.45	3.00
1.36	0.45	3.00
0.27	0.09	3.00

Table B-12: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Access to Emergency Contact

Table B-13: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}	Access Emergency Contact		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	0.33
Sensor Watch	1.00	1.00	0.33
Haptic Smart Cane	3.00	3.00	1.00
Sum	5.00	5.00	1.67

Table B-14: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane	Design Alternative Priorities {PI}
Sensor Pin Chip	0.20	0.20	0.20	0.20
Sensor Watch	0.20	0.20	0.20	0.20
Haptic Smart Cane	0.60	0.60	0.60	0.60
Sum	1.00	1.00	1.00	1.00

Table B-15: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
0.60	0.20	3.00
0.60	0.20	3.00
1.80	0.60	3.00

Table B-16: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Interface with Pre-existing Skills

Table B-17: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}	Interface With Pre-Existing Skills		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	0.20
Sensor Watch	1.00	1.00	0.20
Haptic Smart Cane	5.00	5.00	1.00
Sum	7.00	7.00	1.40

Table B-18: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane	Design Alternative Priorities {PI}
Sensor Pin Chip	0.14	0.14	0.14	0.14
Sensor Watch	0.14	0.14	0.14	0.14
Haptic Smart Cane	0.71	0.71	0.71	0.71
Sum	1.00	1.00	1.00	1.00

Table B-19: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
0.43	0.14	3.00
0.43	0.14	3.00
2.14	0.71	3.00

Table B-20: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Store Frequent Tasks

Table B-21: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W} Criteria Comparison Matrix [C]	Store Frequent Tasks		
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	1.00
Sensor Watch	1.00	1.00	1.00
Haptic Smart Cane	1.00	1.00	1.00
Sum	3.00	3.00	3.00

Table B-22: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W} Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane	Design Alternative Priorities (Pi)
Sensor Pin Chip	0.33	0.33	0.33	0.33
Sensor Watch	0.33	0.33	0.33	0.33
Haptic Smart Cane	0.33	0.33	0.33	0.33
Sum	1.00	1.00	1.00	1.00

Table B-23: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
1.00	0.33	3.00
1.00	0.33	3.00
1.00	0.33	3.00

Table B-24: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Alert of a Physical Object

Table B-25: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}	Alert of Physical Object		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Sensor Pin Chip	1.00	3.00	1.00
Sensor Watch	0.33	1.00	0.33
Haptic Smart Cane	1.00	3.00	1.00
Sum	2.33	7.00	2.33

Table B-26: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane	Design Alternative Priorities {Pi}
Sensor Pin Chip	0.43	0.43	0.43	0.43
Sensor Watch	0.14	0.14	0.14	0.14
Haptic Smart Cane	0.43	0.43	0.43	0.43
Sum	1.00	1.00	1.00	1.00

Table B-27: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
1.29	0.43	3.00
0.43	0.14	3.00
1.29	0.43	3.00

Table B-28: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Inform User of Possible Threats

Table B-29: Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}	Inform User of Possible Threats		
Criteria Comparison Matrix [C]			
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Sensor Pin Chip	1.00	1.00	1.00
Sensor Watch	1.00	1.00	1.00
Haptic Smart Cane	1.00	1.00	1.00
Sum	3.00	3.00	3.00

Table B-30: Normalized Criteria Comparison Matrix

Development of Candidate Set of Criteria Weights {W}				
Criteria Comparison Matrix [C]				
	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane	Design Alternative Priorities {Pi}
Sensor Pin Chip	0.33	0.33	0.33	0.33
Sensor Watch	0.33	0.33	0.33	0.33
Haptic Smart Cane	0.33	0.33	0.33	0.33
Sum	1.00	1.00	1.00	1.00

Table B-31: Consistency Check

Weighted Sum Vector	Design Alternative Priorities	Consistency vector
1.00	0.33	3.00
1.00	0.33	3.00
1.00	0.33	3.00

Table B-32: Consistency Ratio

# of criteria	RI value	Average Consistency	Consistency Index	Consistency Ratio
3.00	0.52	3.00	0.00	0.00

Appendix C

Table C-1: Final Rating Matrix

	Sensor Pin Chip	Sensor Watch	Haptic Smart Cane
Alert of Elevation	0.11	0.11	0.78
Determine Location	0.16	0.19	0.66
Interpret Sensory Information	0.45	0.45	0.09
Access Emergency Contact	0.20	0.20	0.60
Interface With Pre-Existing	0.14	0.14	0.71
Store Frequent Tasks	0.33	0.33	0.33
Alert of Physical Object	0.43	0.14	0.43
Inform User of Possible Threats	0.33	0.33	0.33

Table C-2: Final Rating Matrix

Concept	Alternative Value
Sensor Pin Chip	0.27
Sensor Watch	0.24
Haptic Smart Cane	0.49