Application of the Hierarchical Decision Model in Choosing a Point-and-Shoot Digital Camera

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I. Abstract

Nowadays, choosing the optimum camera became a difficult process due to the large varieties in models and brands available in the market. The objective of the decision making process here is to choose the optimum digital camera for regular consumers who are looking for a point-and-shoot camera. The Hierarchical Decision Model (HDM) methodology will be used to determine the best alternative that meets the consumers' needs. First we determine the important factors considered by potential buyers and identify them as criteria and sub-criteria. Each of these sub-criteria contributes as a part of each major criterion's weight or relative importance. After selecting the criteria, the pair wise comparison is used to determine the relative impact of each criterion / sub-criterion towards the main objective. The model is then validated on ten of the most popular point and shoot cameras in 2008. Once these steps are established, calculations will be made on the model and the best point and shoot camera would be proposed as the optimum alternative.

II. Introduction

The process of transition from the 35 mm film camera towards the digitalized version is still an ongoing process even decades after the commercialization of the first digital camera, with the regular 35mm film cameras becoming more and more obsolete due to the superiority of the basic functionalities of its digital counterparts. Digital cameras has the distinguishing capabilities of saving thousands of pictures in its storage devices at the same time, the ability to view pictures instantly after taking the shot, and the ability to record videos in acceptable quality.

Nowadays, people like to record memories of their lives by taking photos, so cameras which are easy to carry, easy to use, and affordable in price are becoming more and more popular. Therefore, the point-and shoot camera would be a good choice for this purpose, and it has become the mainstream cameras ever since [1]. However, choosing the optimum camera became a difficult process due to the large varieties in models and brands available in the market. In fact, each consumer has their own set of needs and considerations when purchasing a camera. For example, the priority of consideration for some people is price, but others may prioritize image quality or physical characteristics.

Accordingly, in this report, a decision making model will be presented for choosing the optimum digital camera in relation to their costs, technical aspects, and physical characteristics.

III. Objective

The objective of this decision making process is to choose the optimum digital camera for regular consumers who are looking for a point-and-shoot camera. Therefore, our team will apply the Hierarchical Decision Model (HDM) methodology to determine the best alternative that meets the consumers' needs.

IV. The Decision Process

To tackle the problem in a systematic fashion, the holistic approach of the decision making process was first defined. The steps undertaken by the team were as depicted below:

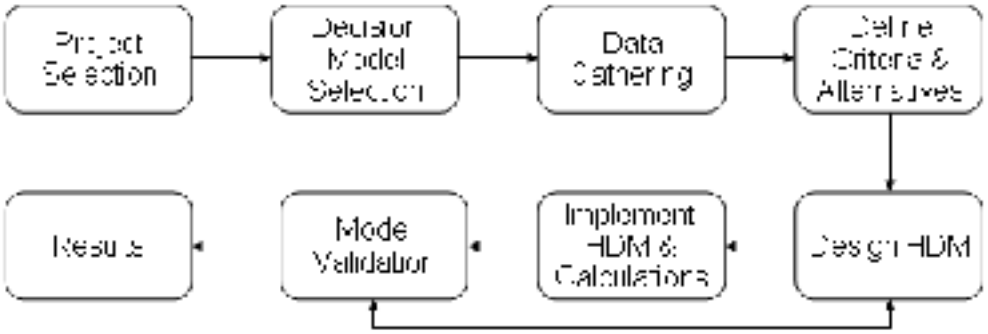


Figure 1: The Decision Process

After the topic was selected, an appropriate decision making model was chosen. In this paper, the hierarchical decision model (HDM) proposed by Dr. D. F. Kocaoglu will be used to formulate the problem and identify the best solution [2]. The HDM process was initiated by first defining the main objective of the model, followed by identifying the most critical factors considered by every consumer before purchasing their digital camera, these aspects are defined in the HDM model as criteria. Each criterion is then broken further more into sub-criteria for more elaboration on the specific features each alternative has. The impact of each criterion on the main objective is then defined using the pair-wise comparison. The hierarchical model diagram is then constructed to provide a holistic view of the model, with the main objective topping the upper level, the criteria and sub-criteria in the descending levels, and the alternatives shown in the bottom level. Finally, each alternative is evaluated in relation to the weights set on each criterion, and the optimum alternative is concluded.

V. Decision model

A. Determining the Criteria / Sub-criteria

In order to get an adequate background of the most important criteria and sub-criteria considered by any potential digital camera buyer, on-line researches were conducted to pinpoint these criteria and sub-criteria. The criteria and sub-criteria were identified by our team members and based on the information of the camera's features and characteristics listed in the general shopping websites such as eBay, yahoo shopping etc. and camera rating website. The process of identifying the final criteria and sub-criteria is to choose the most general and comparable features and characteristics to represent criteria and sub-criteria of this project. The set of criteria and sub-criteria for the decision model were determined as follows:

1. Price: The cost of the camera based on its on-line value.

2. Lens:

- Optical zoom: The physical zoom range of the lens.
- Zoom range max: The digital zoom range for the camera.
- Macro focus range: The close-up zoom for capturing minuscule objects.

3. Image Quality

- Camera resolution: Maximum clarity of pictures – technical capabilities
- Image resolution: Maximum clarity of pictures – image processing capabilities
- Video resolution: Video recording quality.

4. Features

- Face detector: Ability to detect faces in order to give the best shot in accordance to the surrounding lighting conditions.
- Smile capture: Ability to detect smiles to capture genuine pleasant moments.
- Red eye reduction: Reduction of red-eye shots caused by reflection of flash lights.
- Convenience photo mode: Modes for varying lighting conditions (snow, sunny, dark, etc.)

5. Physical Characteristic

- Dimensions: The physical dimensions of the digital camera.
- Weight: The physical weight of the camera.
- LCD Screen Size: The size of the LCD screen in inches.
- Available Colors: Number of colors available for the specific model.

6. Power Supply

- Number of shots: Averaged total number of shots for each battery charge.
- Battery Life: The total number of hours a camera can withstand in standby mode.

B. Determining the Alternatives

To determine the alternatives for the HDM model, we choose top ten point-and-shoot cameras which are rated and tested by PC world Website as the alternatives for this project. There are two major testing of all products under consideration for review applied by PCWorld website. One testing is hands-on testing done by editors and writers who are experts in the product field, and another testing is formal lab testing done by the PCWorld Test Center [3].
The nominees were as follows (See appendix 1 for complete information):

1. Canon Powershot A590IS
2. Canon Powershot SD1100 IS
3. Pentax Optio A40
4. Pentax Optio S12
5. Casio Exilim EX-Z150
6. Casio Exilim EX-Z80
7. Nikon Coolpix S210
8. Canon Powershot SD880 IS
9. Sony Cybershot DSC-W170
10. Pentax Optio V20

C. Assumptions

1. People are satisfied with the alternatives we provide in our data gathering based on Top 10 point-and-shoot cameras in 2008.
2. The brand name is not considered an important criterion, hence will not be included for evaluation.
3. The decision making process will only be limited for the purpose of choosing the optimum point-and shoot cameras and does not include intermediate cameras, Advanced consumer cameras, Prosumer non-SLR cameras, Prosumer SLR cameras and Professional Cameras [4].
4. All the criteria involved in making the decision remain unchanged during the entire process.
5. It is assumed that all the criteria and sub-criteria are the most general factors considered by the general consumer.
6. The data gathering from twelve people including five of our team members and seven experts represents general consumers' preferences.

D. Formulating the HDM

After all the criteria and alternatives were defined, a hierarchical model was constructed to give a general view of the components of the decision making model. The resulted hierarchical model was as follows:

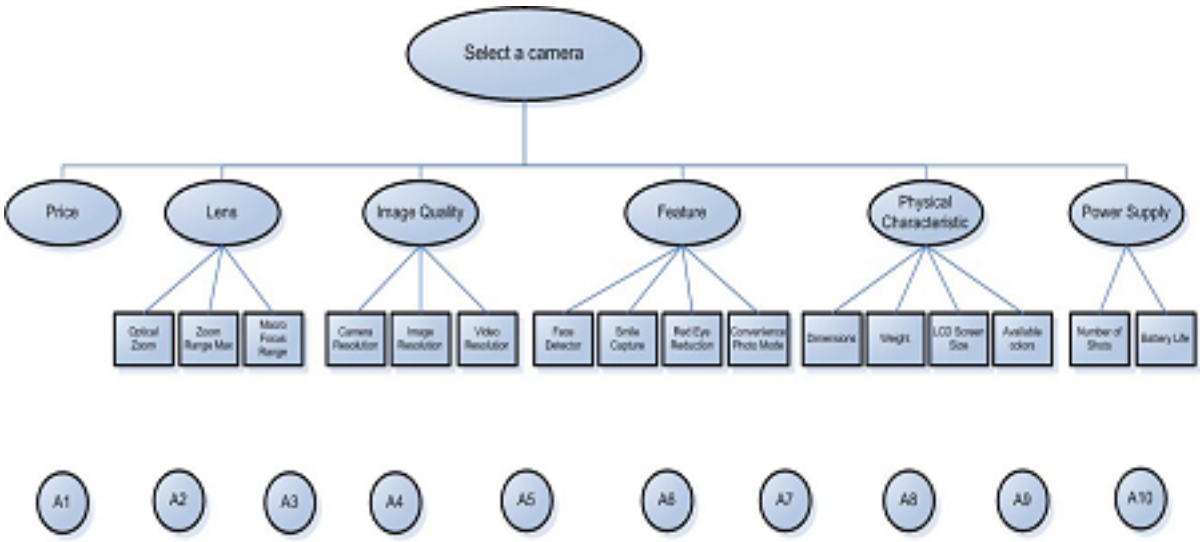


Figure 2: Hierarchical Model

The relative priority and impact of each criterion were defined using the pair-wise comparison method. Each member and some people contributed their own judgments and the results were averaged to form the criteria weights in the HDM. The process was followed by setting the relative impacts of each sub-criterion.

VI. Analysis of the Decision Model

A. Criteria Weighting

a) Determine Relative Priority for each Selection Criterion:

The pair-wise comparison method is applied in calculating the relative priority for each criterion and sub-criterion. We ask each decision maker distribute total of 100 percentages between criteria of each pair in the same level of the hierarchical model [6] and calculate the relative priority of criteria. Under the each criterion, we

use the same method to calculate the relative priority of sub-criteria.

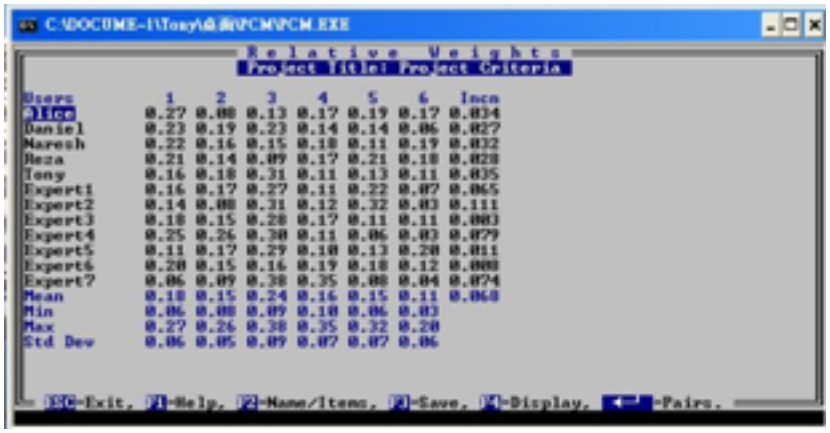
b) Determine Normalized Value

A normalized value can make criteria and sub-criteria possible to be effectively compared the values between each other. They are calculated based on the different type of normalized values used in our data [5]. We can calculate normalized value by dividing a scale ranking of each criterion or sub-criterion by the sum of scale ranking for each criterion and sub-criterion in the same portion. Before we normalize value, we used 1 to 5 scales as our measurement of sub-criteria except price and feature criteria. In order to avoid the confusion that the higher values with the lower relative priority, we use reciprocal of the price. Since the result of reciprocal of the price is too small, we use the result of reciprocal of the price times 500. We also use couples ways to rank different situations. For, example, we ranked the cameras by five levels. First of all, we subtract the highest zoom range max number with the lowest, and then divided by five. Thus, if a camera's zoom range max value is between 172 and 180, then it is Rank 5. Hence, the same methods can be applied in some criteria like Macro focus range, camera resolution, dimensions, weight, number of shots and battery life. However, for the "Yes" or "No", we choose binary method to rank. Because "yes" means our need, we rank "yes" for 1; otherwise we rank "no" for 0. The result table for each criterion and sub-criterion are shown in Appendix 2.

B. Implementing Decision Model

We use pair comparison to calculate the value of weight for each level of criteria and sub-criteria. The PCM result shown as following:

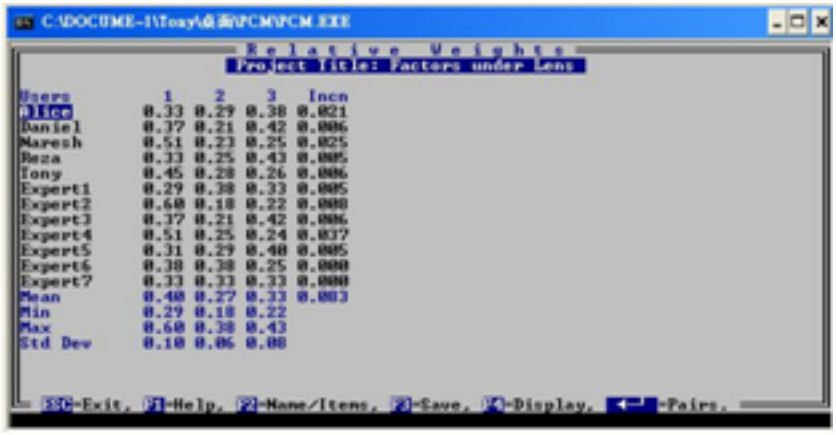
1. Performing pair-wise comparison and relative weight for the major criteria:



Ÿ The relative weights were determined as follows:

Price	Lens	Image Quality	Feature	Physical Characteristic	Power Supply
0.18	0.15	0.24	0.16	0.15	0.11

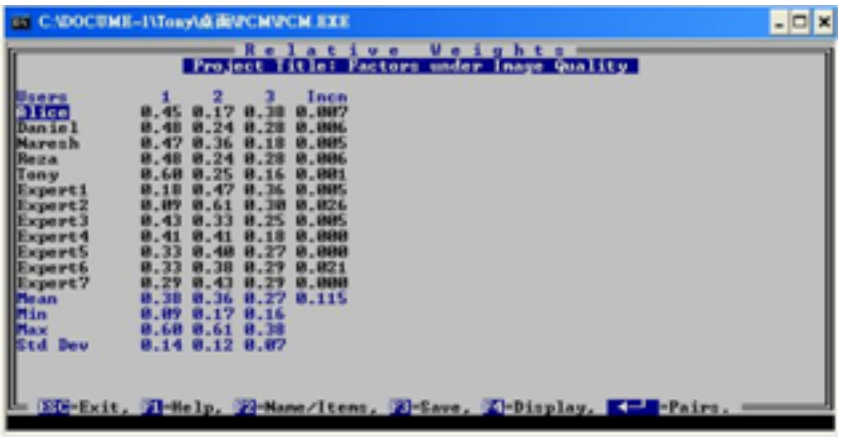
2. Performing pair-wise comparison and relative weight for sub-criteria under lens:



Ÿ Relative weights for sub-criteria under lens:

Optical Zoom	Max Zoom Range	Macro Focus Range
0.40	0.27	0.33

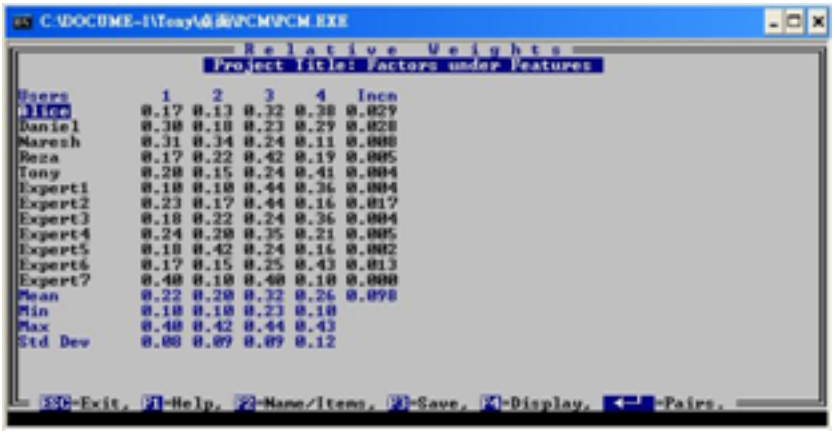
3. Performing pair-wise comparison and relative weight for sub-criteria under image quality:



Ÿ Relative weights for sub-criteria under image quality:

Camera Resolution	Image Resolution	Video Resolution
0.38	0.36	0.27

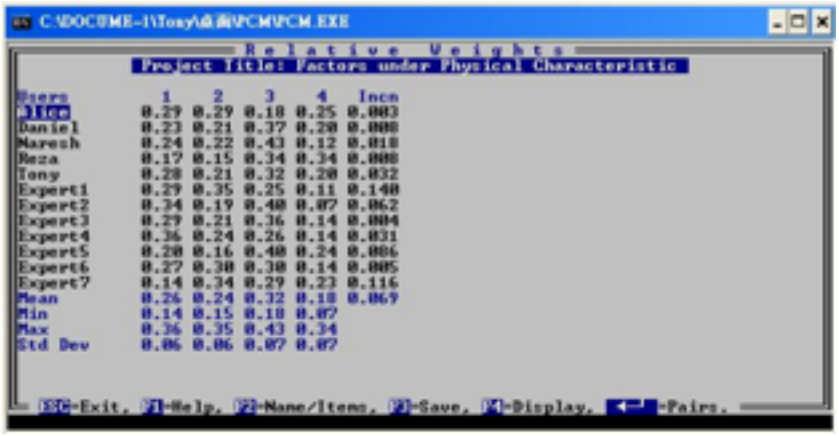
4. Performing pair-wise comparison and relative weight for sub-criteria under features:



Ÿ Relative weights for sub-criteria under features:

Face Detector	Smile Capture	Red Eye Reduction	Convenience Photo Mode
0.22	0.20	0.32	0.26

5. Performing pair-wise comparison and relative weight for sub-criteria under physical characteristic:



Ÿ Relative weights for sub-criteria under physical characteristics:

Dimension	Weight	LCD Screen Size	Available Colors
0.26	0.24	0.32	0.18

6. Performing pair-wise comparison of relative weights for sub-criteria under power supply:

Number of Shots	Battery Life
0.49	0.51

After getting the result from PCM, we create the table below (figure 3). The table shows the value of weight for each criterion and sub-criterion. We calculate the weight for each sub-criterion with respect to its main criterion multiply by those weights as shown in Figure3.

Criteria	Weight	weight	Final
Price	0.18		0.18
Lens	0.15		
Optical Zoom		0.4	0.06
zoom range Max		0.27	0.0405
Macro Focus Range		0.33	0.0495
Image Quality	0.24		
Camera Resolution		0.38	0.0912
Image Resolution		0.36	0.0864
Video Resolution		0.27	0.0648
Feature	0.16		
Face detector		0.22	0.0352
Smile capture		0.2	0.032
Red eye reduction		0.32	0.0512
Convenience photo mode		0.26	0.0416
Physical Characteristic	0.15		
Dimensions		0.26	0.039
Weight		0.24	0.036
LCD Screen Size		0.32	0.048
Available colors		0.18	0.027
Power Supply	0.11		
Number of shots		0.49	0.0539
Battery Life		0.51	0.0561
Total			0.9924

Figure3: Total weights of criteria and sub-criteria

To calculate the final value for each camera, we multiplied the weights from each criterion and sub-criterion and normalized value for each camera. From the matrix below, take the first matrix times the first column of the second matrix and we can get the final value for the first alternative. The same calculation is for the rest of the alternatives.

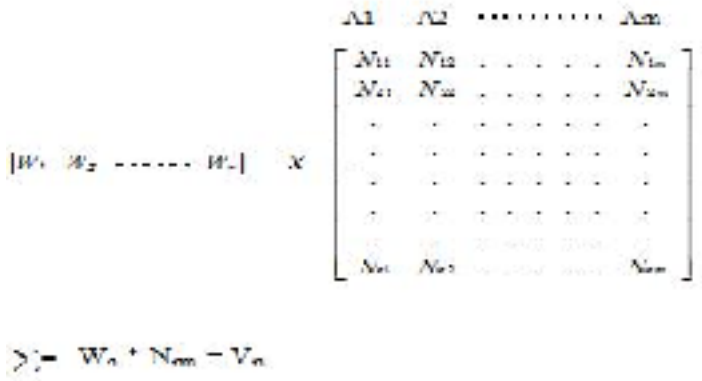


Figure 4: Matrix

VII. Results

As seen from the results reflected in the figure3 above , the overall weighted score for all the criteria is calculated, then they are summed together to attain the weighted score and a decision is reached. In the table we can see the matrix of specifications of all our alternatives and their corresponding weighted values. We were able to construct the result matrix by normalizing the weight of each corresponding criterion.

From the Figure 5 we will be able to find the value of each alternative by looking at the final column where it is normalized and multiplied by hundred. To make it easier it has been assigned a valued between 1 to 5 where 5 is being the best and 1 not confirming to the requirements, and for some sub-criteria, we apply binary method which is 1 and 0 where 1 is having specific feature; 0 is not having.

Based on the figure 5, we can see the product of weight and all sub-criteria normalized value of each alternative. The highest ranking is Sony Cybershot DSC-W170 with a score of 12.19 followed by Canon PowerShot SD880 IS (11.63), Pextax Optio S12 (11.27), Canon Powershot SD1100 IS (10.02), Canon PowerShot A590IS (9.89), Casio Exilim EX-Z150 (9.70), Pentax Optio A40 (9.698), Pentax Optio V20 (9.36), Nikon Coolpix S210 (7.82), and Casio Exilim EX-Z80 (7.79). As the result, the best alternative under our specified criteria is Sony Cybershot DSC-W170.

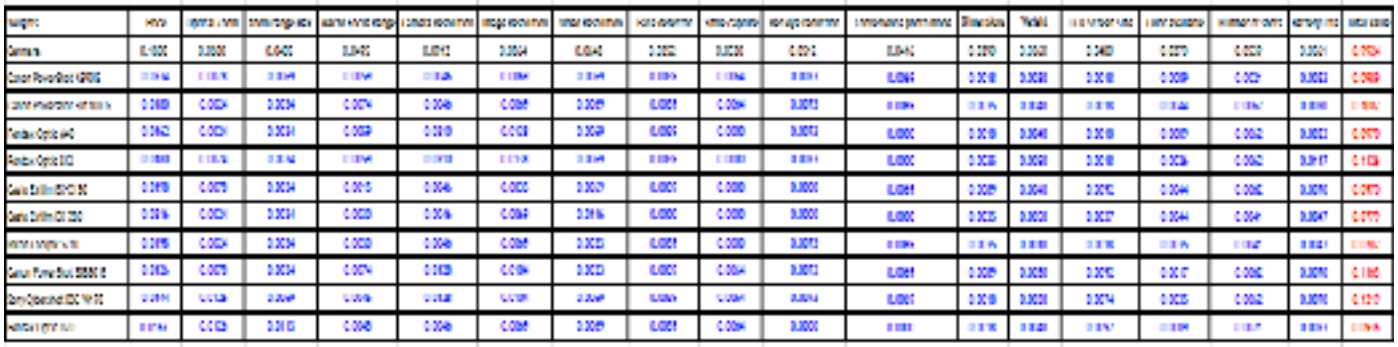


Figure 5

VIII. Lessons learned

- Ø One of the real challenges in constructing an HDM lies in the process of quantification of qualitative data. On the other hand, finding the optimum alternative becomes less difficult when all the data are available in measurable numerical form. However, when the difference between these numbers is miniscule, it obligates the creators to further improvise in making a clear distinction between these data.
- Ø Most of the electronic devices found on the market today are already reviewed by experts and previous owners which help potential buyers to shape their judgments. However, the value in constructing an HDM at this point is further determining the exact preferences of the buyers instead of the general population's preferences.
- Ø Constructing the HDM requires a systematic holistic approach which helps the potential buyer to explore other areas of concern that were never considered before, and might affect later in choosing the optimum alternative.
- Ø With variety of information available, there are many websites where consumers can gather result of ranking on different of product. However, most of the results do not involve the reference of the decision makers. By using HDM, the final result will be much more accurate for the consumers' needs.

IX. Recommendation

- Ø In the process of choosing the best alternative camera from a pool of different camera segments, such as the "Advanced Amateur" professional cameras, some changes may occur to the existing model. Such changes can be in the form of different impact levels for each criterion, the creation (or elimination) of new

criteria/sub-criteria, and the selection of new set of alternatives. However, the model constructed in this report may be used as a general template to select a point-and-shoot camera due to the generality of its criteria.

- Ø The model can be improved by getting real time data from real experts.

X. Conclusion

In the conclusion, important lesson learned from this project is that decision making models can be very handy in making decisions. By determining the key criteria from the beginning we were able to rank our choices as per our preferences. The weights calculated in our case gave us approximated results; a higher level of accuracy could have been achieved by including a larger number of people in the pair-wise comparison phase.

The Model/Project can be expanded by adding more criteria, sub-criteria and by getting experts' judgments in the photography industry to do the pair-wise comparison and for the matter of fact also help in choosing the appropriate criteria and sub-criteria. This project can be extended to make a decision model for choosing a professional camera. In general this project can be modified as per the preference of a particular group to satisfy their need for a Good Camera.

XI. Reference

[1] InfoTrends, North American Consumer Digital Camera Forecast 2008-2013, June 3, 2008

[2] D.F. Kocaoglu, "Hierarchical Decision Modeling", PSU ETM EMGT 530 Class Notes, winter 2009

[3] Tim Moynihan (2003) Top 10 Point-and-Shoot Cameras, http://www.pcworld.com/article/122812/how_we_test.html

[4] David D. Busch, Digital Photography All-in-One Desk Reference for Dummies, Wiley Publishing, Inc. 3rd Edition.

[5] Agilent Technologies, "How are normalized values calculated from the raw data initially loaded?" http://www.chem.agilent.com/en-US/Support/FAQs/Informatics/GeneSpring%20GX/Normalization/Pages/KB001070.aspx

[6] Cleland, David I. and Dundar F. Kocaoglu (1981) Engineering Management, McGraw-Hill, New York, p449,

APPENDIX1: Complete information of alternatives [3]

Camera Name/Series	Canon PowerShot A590IS	Canon Powershot SD1100 IS	Canon PowerShot SD880 IS
			
Price (USD)	150	200	249
Dimensions (Inches)	3.7 by 2.6 by 1.6	3.4 by 2.2 by 0.9	3.7 by 0.9 by 2.2
Weight (lbs)	0.29	0.28	0.24
Camera Resolution (Mega Pixels)	8.0	8.0	10.0
Zoom range max	140 mm	114 mm	112 mm
Optical zoom	X 4	X 3	X 4
Colors Available	1	5	2
Battery Life (Hours)	135.5	136	155.25
Number of Shots (per charge)	248	250	283
Face detector	Y	Y	Y
Smile Capture	Y	N	N
Red-eye Reduction	Y	Y	Y
Convenience Photo Modes	Y	N	Y

Camera Name/Series	Casio Exilim EX-Z150	Casio Exilim EX-Z80	Nikon Coolpix S210
			
Price (USD)	180	160	180
Dimensions (Inches)	3.8 by 0.8 by 2.3	3.7 by 2.0 by 0.8	3.6 by 2.2 by 0.7
Weight (lbs)	0.28	0.22	0.49
Camera Resolution (Mega Pixels)	8.29	8.29	8.29
Zoom range max	112 mm	114 mm	114 mm
Optical zoom	X 4	X 3	X 3
Colors Available	5	6	4
Battery Life (Hours)	153.20	204.20	149.0
Number of Shots (per charge)	269	371	272
Face detector	Y	Y	N
Smile Capture	Y	N	N
Red-eye Reduction	Y	Y	N
Convenience Photo Modes	Y	N	N

Camera Name/Series	Pentax Optio A40	Pentax Optio S12	Pentax Optio V20	Sony Cybershot DSC-W170
				
Price (USD)	230	200	230	220
Dimensions (inches)	3.9 by 2.2 by 0.9	3.1 by 2.1 by 0.8	3.8 by 2.2 by 0.9	3.7 by 2.3 by 0.9
Weight (lbs)	0.29	0.24	0.29	0.31
Camera Resolution (Mega Pixels)	12.43	12.4	8.5	10.1
Zoom range max	111 mm	111 mm	180 mm	140 mm
Optical zoom	X 3	X 3	X 5	X 5
Colors Available	1	3	1	4
Battery Life (Hours)	150	132.75	166	160
Number of Shots (per charge)	310	211	302	310
Face detector	Y	Y	Y	Y
Smile Capture	Y	Y	N	Y
Red-eye Reduction	Y	N	N	Y
Convenience Photo Modes	Y	N	Y	Y

APPENDIX2 : Original Data and Normalized Value

- Measurement 1: Cost

		Price $	500/C	Normalized Value
1	[illegible]	150	3.33	0.13
2	[illegible]	200	2.50	0.10
3	[illegible]	230	2.17	0.09
4	[illegible]	200	2.50	0.10
5	[illegible]	180	2.78	0.11
6	[illegible]	160	3.13	0.12
7	[illegible]	180	2.78	0.11
8	[illegible]	299	1.67	0.07
9	[illegible]	250	2.00	0.08
10	[illegible]	230	2.17	0.09
			Total	Total
			25.03	1.00

- Measurement 2: Optical Zoom

		Optical Zoom	Rank	Normalized Value
1	[illegible]	4	3	0.13
2	[illegible]	3	1	0.04
3	[illegible]	3	1	0.04
4	[illegible]	3	1	0.04
5	[illegible]	4	3	0.13
6	[illegible]	3	1	0.04
7	[illegible]	3	1	0.04
8	[illegible]	4	3	0.13
9	[illegible]	5	5	0.21
10	[illegible]	5	5	0.21
			Total	Total
	[illegible]		24	1.00

- Measurement 3: Max Zoom Range

		zoom range Max (mm)	Rank	Normalized Value
1	[illegible]	140 mm	3	0.17
2	[illegible]	114 mm	1	0.06
3	[illegible]	111 mm	1	0.06
4	[illegible]	111 mm	1	0.06
5	[illegible]	112 mm	1	0.06
6	[illegible]	114 mm	1	0.06
7	[illegible]	114 mm	1	0.06
8	[illegible]	112 mm	1	0.06
9	[illegible]	140 mm	3	0.17
10	[illegible]	180 mm	5	0.28
			Total	Total
[illegible]			18	1.00

- Measurement 4: Macro Focus Range

		Macro Focus Range (mm)	Rank	Normalized Value
1	[illegible]	2 - 18 in. (w)	4	0.12
2	[illegible]	1.2 - 19.2 in. (w)	5	0.15
3	[illegible]	2.36 - 5.91 in. (w)	4	0.12
4	Pentax Optio S12	2.36 - 5.91 in. (w)	4	0.12
5	[illegible]	5.91 - 19.69 in. (w)	1	0.03
6	[illegible]	3.94 - 19.69 in. (w)	2	0.06
7	[illegible]	4 in. to Infinity (w)	2	0.06
8	[illegible]	0.8 - 19.69 in. (w)	5	0.15
9	[illegible]	3.94 in. to Infinity (w)	3	0.09
10	[illegible]	3.96 - 19.68 in. (w)	3	0.09
			Total	Total
[illegible]			33	1.00

- Measurement 5: Camera Resolution

		Camera Resolution (Megapixel)	Rank	Normalized Value
1	[illegible]	[illegible]	1	0.05
2	[illegible]	[illegible]	1	0.05
3	Pentax Optio A40	12.43 Megapixel	5	0.23
4	Pentax Optio S12	12.4 Megapixel	5	0.23
5	Casio Exilim EX-Z150	4.09 Megapixel	1	0.05
6	Casio Exilim EX-Z80	4.09 Megapixel	1	0.05
7	Nikon Coolpix S210	4.09 Megapixel	1	0.05
8	[illegible]	10.3 Megapixel	3	0.14
9	Sony Cybershot DSC-W170	10.1 Megapixel	3	0.14
10	Pentax Optio W20	[illegible]	1	0.05
			Total	Total
[illegible]			22	1.00

- Measurement 6: Image Resolution

		Image Resolution	Highest	Rank	Normalized Value
1	Canon Powershot A590 IS	[illegible]	3264x2448	2	0.08
2	Canon Powershot SD1100 IS	[illegible]	3264x2448	2	0.08
3	Pentax Optio A40	[illegible]	4000x3000	4	0.16
4	Pentax Optio S12	[illegible]	4000x3000	4	0.16
5	Casio Exilim EX-Z150	[illegible]	3264x2176	1	0.04
6	Casio Exilim EX-Z80	[illegible]	3264x2448	2	0.08
7	Nikon Coolpix S210	[illegible]	3264x2448	2	0.08
8	Canon Powershot SX410 IS	[illegible]	3648x2736	3	0.12
9	Sony Cybershot DSC-W170	[illegible]	3648x2736	3	0.12
10	Pentax Optio W20	[illegible]	3264x2448	2	0.08
			Total	Total	
			25	1.00	

- Measurement 7: Video Resolution

		Video Resolution	Rank	Normalized Value
1	Canon PowerShot A590IS	320 x 240 - 640 x 480 (VGA)	3	0.11
2	Canon Powershot SD1100 IS	320 x 240 - 640 x 480 (VGA)	3	0.11
3	Pentax Optio A40	320 x 240 - 640 x 480 (VGA)	3	0.11
4	Pentax Optio S12	320 x 240 - 640 x 480 (VGA)	3	0.11
5	Casio Exilim EX-Z150	320 x 240 - 640 x 480 (VGA)	3	0.11
6	Casio Exilim EX-Z80	320 x 240 - 640 x 480 (VGA) - 848 x 480	5	0.18
7	Nikon Coolpix S210	640 x 480 (VGA)	1	0.04
8	Canon PowerShot SD880 IS	640 x 480 (VGA)	1	0.04
9	Sony Cybershot DSC-W170	320 x 240 - 640 x 480 (VGA)	3	0.11
10	Pentax Optio V20	320 x 240 - 640 x 480 (VGA)	3	0.11
			Total	Total
(5)320 x 240 - 640 x 480 (VGA) - 848 x 480 (3) 320 x 240 - 640 x 480 (VGA) (1) 640 x 480 (VGA)			28	1.00

- Measurement 8: Face detector

		Face detector	Rank	Normalized Value
1	[illegible]	Y	1	0.11
2	[illegible]	Y	1	0.11
3	[illegible]	Y	1	0.11
4	[illegible]	Y	1	0.11
5	[illegible]	Y	1	0.11
6	[illegible]	N	0	0.00
7	[illegible]	Y	1	0.11
8	[illegible]	Y	1	0.11
9	[illegible]	Y	1	0.11
10	[illegible]	Y	1	0.11
			Total	Total
	[illegible]		9	1.00

- Measurement 9: Smile capture

		Smile capture	Rank	Normalized Value
1	[illegible]	Y	1	0.2
2	[illegible]	Y	1	0.2
3	[illegible]	N	0	0
4	[illegible]	N	0	0
5	[illegible]	N	0	0
6	[illegible]	N	0	0
7	[illegible]	N	0	0
8	[illegible]	Y	1	0.2
9	[illegible]	Y	1	0.2
10	[illegible]	Y	1	0.2
			Total	Total
	[illegible]		5	1.00

- Measurement 10: Red eye reduction

		Red eye reduction	Rank	Normalized Value
1	[illegible]	Y	1	0.142857143
2	[illegible]	Y	1	0.142857143
3	[illegible]	Y	1	0.142857143
4	[illegible]	Y	1	0.142857143
5	[illegible]	N	0	0
6	[illegible]	N	0	0
7	[illegible]	Y	1	0.142857143
8	[illegible]	Y	1	0.142857143
9	[illegible]	Y	1	0.142857143
10	[illegible]	N	0	0
			Total	Total
	(7) Y (3) N		7	1.00

- Measurement 11: Convenience photo mode

		Convenience photo mode	Rank	Normalized Value
1	Canon PowerShot A590IS	Y	5	0.16
2	Canon Powershot SD1100 IS	Y	5	0.16
3	Pentax Optio A40	N	1	0.03
4	Pentax Optio S12	N	1	0.03
5	Casio Exilim EX-Z150	Y	5	0.16
6	Casio Exilim EX-Z80	N	1	0.03
7	Nikon Coolpix S210	Y	5	0.16
8	Canon PowerShot SD880 IS	Y	5	0.16
9	Sony Cybershot DSC-W170	Y	5	0.16
10	Pentax Optio V20	N	1	0.03
			Total	Total
	(5) Y (1) N		34	1.00

- Measurement 12: Dimension

		Dimensions	square measure	Rank	Normalized Value
1	Canon PowerShot A590IS	3.7 by 2.6 by 1.6	9.62	1	0.05
2	Canon Powershot SD1100 IS	3.4 by 2.2 by 0.9	7.48	2	0.09
3	Pentax Optio A40	3.9 by 2.2 by 0.9	8.58	1	0.05
4	Pentax Optio S12	3.4 by 2.1 by 0.8	7.14	2	0.09
5	Casio Exilim EX-Z150	3.8 by 0.8 by 2.3	3.04	5	0.23
6	Casio Exilim EX-Z80	3.5 by 2.0 by 0.8	7	2	0.09
7	Nikon Coolpix S210	3.5 by 2.2 by 0.7	7.7	2	0.09
8	Canon PowerShot SD880 IS	3.7 by 0.9 by 2.2	3.33	5	0.23
9	Sony Cybershot DSC-W170	3.7 by 2.3 by 0.9	8.51	1	0.05
10	Pentax Optio V20	3.8 by 2.2 by 0.9	8.36	1	0.05
				Total	Total
(5) 3-4.33, (4) 4.34-5.66, (3) 5.67-6.99, (2) 7-8.32 (1) 8.33-9.65				22	1.00

- Measurement 13: Weight

		Weight(lbs)	Rank	Normalized Value
1	Canon PowerShot A590IS	0.39	3	0.08
2	Canon Powershot SD1100 IS	0.28	4	0.11
3	Pentax Optio A40	0.29	4	0.11
4	Pentax Optio S12	0.24	5	0.14
5	Casio Exilim EX-Z150	0.28	4	0.11
6	Casio Exilim EX-Z80	0.22	5	0.14
7	Nikon Coolpix S210	0.49	1	0.03
8	Canon PowerShot SD880 IS	0.34	3	0.08
9	Sony Cybershot DSC-W170	0.31	3	0.08
10	Pentax Optio V20	0.29	4	0.11
			Total	Total
	(5) 0.2-0.25, (4)0.26-0.3 (3)0.31-0.35 (2)0.36-0.4 (1)0.45-0.5		36	1.00

- Measurement 14: LCD Screen Size

		LCD Screen Size	Rank	Normalized Value
1	Canon PowerShot A590IS	2.5	1	0.04
2	Canon Powershot SD1100 IS	2.5	1	0.04
3	Pentax Optio A40	2.5	1	0.04
4	Pentax Optio S12	2.5	1	0.04
5	Casio Exilim EX-Z150	3	5	0.19
6	Casio Exilim EX-Z80	2.6	2	0.08
7	Nikon Coolpix S210	2.5	1	0.04
8	Canon PowerShot SD880 IS	3	5	0.19
9	Sony Cybershot DSC-W170	2.7	4	0.15
10	Pentax Optio V20	3	5	0.19
			Total	Total
	(5) 2.91-3 (4) 2.8-2.89 (3) 2.7-2.79 (2) 2.6-2.69 (1) 2.5-2.59		26	1.00

- Measurement 15: Color Available

		Color available	Rank	Normalized Value
1	Canon PowerShot A590IS	1	1	0.03
2	Canon Powershot SD1100 IS	5	5	0.16
3	Pentax Optio A40	1	1	0.03
4	Pentax Optio S12	3	3	0.10
5	Casio Exilim EX-Z150	5	5	0.16
6	Casio Exilim EX-Z80	6	5	0.16
7	Nikon Coolpix S210	4	4	0.13
8	Canon PowerShot SD880 IS	2	2	0.06
9	Sony Cybershot DSC-W170	4	4	0.13
10	Pentax Optio V20	1	1	0.03
			Total	Total
	(5)5-6 (4) 4 (3) 3 (2)2 (1)1		31	1.00

- Measurement 16: Number of Shots

		Number of shots	Rank	Normalized Value
1	Canon PowerShot A590IS	248	1	0.04
2	Canon Powershot SD1100 IS	299	3	0.12
3	Pentax Optio A40	250	3	0.12
4	Pentax Optio S12	371	5	0.12
5	Casio Exilim EX-Z150	302	3	0.12
6	Casio Exilim EX-Z80	272	2	0.08
7	Nikon Coolpix S210	283	2	0.08
8	Canon PowerShot SD880 IS	310	3	0.12
9	Sony Cybershot DSC-W170	310	3	0.12
10	Pentax Optio V20	241	1	0.04
			Total	Total
	(5)346-371 (4) 320-345 (3)294-319 (2) 268-293 (1) 241-267		26	1.00

- Measurement 17: Battery Life

		Battery Life	Rank	Normalized Value
1	Canon PowerShot A590IS	135.5	1	0.04
2	Canon Powershot SD1100 IS	163.25	3	0.13
3	Pentax Optio A40	136	1	0.04
4	Pentax Optio S12	204.25	5	0.21
5	Casio Exilim EX-Z150	166	3	0.13
6	Casio Exilim EX-Z80	149.5	2	0.08
7	Nikon Coolpix S210	155.25	2	0.08
8	Canon PowerShot SD880 IS	169	3	0.13
9	Sony Cybershot DSC-W170	169	3	0.13
10	Pentax Optio V20	132.75	1	0.04
			Total	Total
	(5) 191-205 (4)176-190 (3) 161-175 (2) 146-160 (1) 130-145		24	1.00

Measurement Table:

Criteria	Measurement
Price	500 / price
Lens	
Optical Zoom	(5) X 5, (3) X 4, (1) X 3
zoom range Max	(5) 172~180,(4) 157~171,(3) 140~153,(2) 125~139,(1) 110~124 (mm)
Macro Focus Range	(5) 0.8 -1.82, (4)1.83 -2.85, (3) 2.86 -3.88, (2)3.89 -4.9, (1) 5.0 -6.02 (mm)
Image Quality	
Camera Resolution	(5) 12~13 , (4) 11~12, (3) 10~11, (2)9~10, (1)8~9 (Megapixel)
Image Resolution	(4) 4000 X 3000 (3) 3648 X 2736 (2) 3264 X 2448 (1) 3264 X 2176
Video Resolution	(5)320 x 240 640 x 480 848 x 480 (3) 320 x 240 640 x 480 (1) 640 x 480
Feature	
Face detector	Binary (1) Y (0) N
Smile capture	Binary (1) Y (0) N
Red eye reduction	Binary (1) Y (0) N
Convenience photo mode	Binary (1) Y (0) N
Physical Characteristic	
Dimensions	(5) 0.5~0.8, (4) 0.9~1.2, (3) 1.3~1.6, (2) 1.7~2.0 (1) 2.1~2.3 (Inch)
Weight	(5) 0.2~0.25, (4)0.26~0.3 (3)0.31~0.35 (2)0.36~0.4 (1)0.45~0.5 (lbs)
LCD Screen Size	(5) 2.91 -3 (4) 2.8 -2.89 (3) 2.7 -2.79 (2) 2.6 -2.69 (1) 2.5 -2.59 (Inch)
Available colors	(5)5~6 (4) 4 (3) 3 (2)2 (1)1 (quantity)
Power Supply	
Number of shots	(5)346~371 (4) 320~345 (3)294~319 (2) 268~293 (1) 241~257 (quantity)
Battery Life	(5) 191 -205 (4)176 -190 (3) 161 -175 (2) 146 -160 (1) 130 -145 (hour)

APPENDIX3: Group Pair-Wise Comparison

Ÿ Pair-wise comparison

Criteria

Price			Lens
Price			Image Quality
Price			Feature
Price			Physical Characteristic
Price			Power Supply
Lens			Image Quality
Lens			Feature
Lens			Physical Characteristic
Lens			Power Supply
Image Quality			Feature
Image Quality			Physical Characteristic
Image Quality			Power Supply
Feature			Physical Characteristic
Feature			Power Supply
Physical Characteristic			Power Supply

Lens

Optical Zoom			zoom range Max
Optical Zoom			Macro Focus Range
zoom range Max			Macro Focus Range

Image Quality

Camera Resolution			Image Resolution
Camera Resolution			video Resolution
Image Resolution			video Resolution

Feature

Face detector			Smile capture
Face detector			Red eye reduction
Face detector			Convenience photo mode
Smile capture			Red eye reduction
Smile capture			Convenience photo mode

Red eye reduction			Convenience photo mode

Physical Characteristic

Dimensions			Weight
Dimensions			LCD Screen Size
Dimensions			Available colors
Weight			LCD Screen Size
Weight			Available colors
LCD Screen Size			Available colors

Power Supply

Number of Shot	Battery Life