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DEVELOPMENT OF AN ASSESSMENT FRAMEWORK FOR IT PRODUCTS AND USER INTERFACE SERVICES

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Abstract. *This study demonstrates an evaluation framework for the user interface of drone products that enables to effectively identify their usability. The drone market has shown steady growth recently. However, some important drawbacks of its product interface applications are: 1) several products are controlled with one or two applications to save manufacturing cost, 2) applications do not replace the existing controller, and 3) no standard specification for the applications exists. To tackle the above issues, this study performs a user interface evaluation on 15 products for five major brands with 10 associated applications. A modified Competitive Benchmarking Chart is proposed to examine the market strategy for each company based on derived user interface score and price. This proposed framework would be effective to design hardware and software controller standards for drones and to evaluate hybrid products and applications interface.*
Keywords: User interface, Drone controller interface, IT product, Interface assessment methodology, Competitive Benchmarking Chart

1. **Introduction.** The fourth industrial revolution has led to a global interest in the development of novel IT products and services [1]. Originally developed for military services, drone is a powerful IT product, which has several crucial industrial and personal applications encompassing public sectors, filming, and unmanned delivery [2,3]. This has ensued a tremendous growth in the drone market, along with the inception of several manufacturers as well as product families with different shapes, sizes, and usage. Recently, hardware controllers are being used as applications for mobile devices. As with several IT products and services, the product and application-type services for drones are now applied in hybrid form. Further, users are confused by the fact that the existing hardware controllers are being applied to mobile devices as it is, and there is no standard interface for this.

Therefore, development of a useful and user-friendly interface is crucial to receive good user response [4]. Researchers have proposed several methods to evaluate the usability of individual products and services [5-8]. A majority of these recent studies have demonstrated methods for evaluating users' affects and user experiences [9]. However, research on hybrid/novel product and service is lacking. Although, there are several technical reports on drones, the human-machine interaction aspect of its interface evaluation is insufficient [10]. To this end, we have developed and tested a methodology to evaluate the user interface of a hybrid product and service with drone as a medium.

The paper is organized as follows. Section 2 presents a literature review of the existing methods. Section 3 provides an overview of our methodology for product and service User Interface (UI) assessments. Sections 4 and 5 provide the results on actual cases, and their

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interpretation and visualization, respectively. Some important conclusions are presented in Section 6.

2. **Literature Review.** There are several reported studies on the evaluation of products and services [11-15]. Some common methods are heuristic, benchmark, and System Usability Scale (SUS) evaluations, which assess usability and user experience [11-13]. These methods are useful for the improvement and evaluation of individual products. Most of these methods have iterative design, and are aimed at enhancing quality, before and after the development of product/service and internal design.

Compared to the commonly used evaluation method, the Competitive Benchmarking Chart method can compare and analyze various levels (e.g., for brand, product group) [14]. From the user's perspective, the product strategy should be developed based on its requirement and importance. This method modifies the above condition by evaluating the interface of drones' products and applications to deduce its importance. Here the advantage is that the method is not exclusive for a particular product or service.

The KANO model is used to interpret the strategy of a product or service in quality engineering domain [15]. Depending upon the consumer requirements, there are three dual quality attributes: Attractive, One-dimensional, and Must-be. It is important for companies to provide a strategic framework in order to improve the market dominance. In this study, we attempt to analyze the user interface development strategy based on one-dimensional quality requirements of the KANO model.

3. **Methodology.** Our experiment involved 27 male and 23 female subjects, with mean age of 21.4 years ($\pm$1.21). They were employed regardless of their drone experience. For reference, five subjects tried to control the drone, and one of them actually owned one.

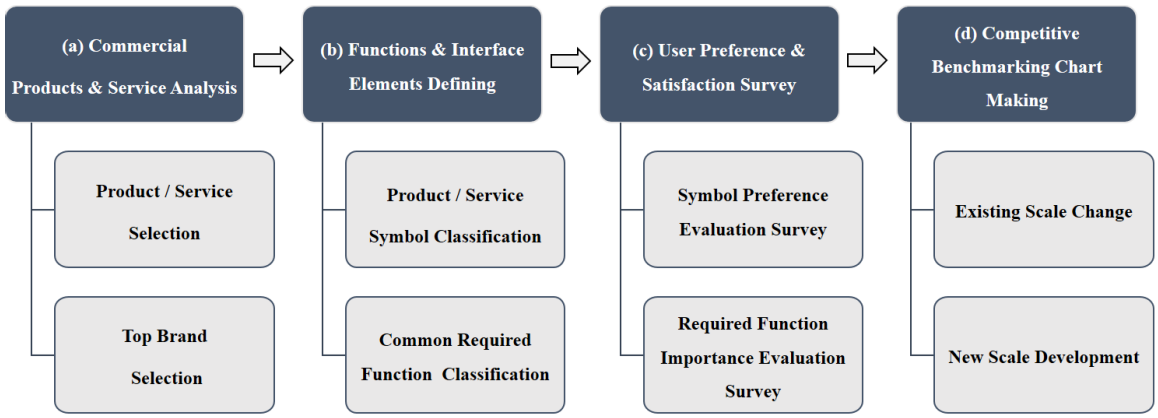

FIGURE 1. Schematic of the methodology

The drones' product and service interface evaluation method was based on developing a Competitive Benchmarking Chart. These evaluations have the advantage of being integrated at each brand, product, and application level. The method comprises of the following steps: (a) analysis of commercial products and service, (b) defining functions and interface elements, (c) user preference and satisfaction survey, and (d) making a Competitive Benchmarking Chart (Figure 1). The detailed procedure is as follows.

(a) Conducting market research: We have employed the drones as a representative IT product. Skylogic Research [16] selected the following top five brands based on the drone market share in 2018: DJI, Parrot, SYMA, Yuneec, and Autel. It is important to note that the hardware or software controller application is included in this process, and it is selected as the currently circulated drones. Overall, 15 drone products, and 10 interlocking applications were investigated for representative functions and interface elements.

(b) Representative functions and interface elements: These were derived based on survey conducted in the previous step. For comparison, common representative functions were integrated and eliminated. We extracted only those symbols, which appear as interface elements on both physical controller as well as the application. Table 1 summarizes the representative functions and interface elements that appear in 15 drones and 10 associated applications.

Table 1. Analysis results for representative functions and symbols

Company	DJI					Parrot			SYMA			Yuneec		Autel	
Product	Spark	Phantom 4 pro	Inspire 2	Mavic Pro	Tello	ANAFI	Bebop2 power	MAMBO	X25PRO	Z1	X22W	Mantis Q	Typhoon H plus	EVO	X-Star premium
APP	DJI GO 4				Tello	FREELIGHT 6	FREELIGHT PRO	FREELIGNT MINI	SYMA FLY		SYMA GO	Yuneec pilot	Joystick	Autel explorer	X-Star
Rise															
Drop															
Turn Left															
Turn Right															
Forward															
Backward															
Move Left															
Move Right															
Return home points					-			-							
Remaining drone battery indicator	92%	92%	92%	92%	92%	92%	92%	-				92%	92%	92%	
General Settings															
Takeoff / landing						LANDING TAKE-OFF	LANDING TAKE-OFF	LANDING TAKE-OFF							
Camera / video conversion							-	-							-
Flight Status Display	H : 9.6m D : 9.6m S : 1.1m/s	H : 9.6m D : 9.6m S : 1.1m/s	H : 9.6m D : 9.6m S : 1.1m/s	H : 9.6m D : 9.6m S : 1.1m/s	H : 9.6m D : 9.6m S : 1.1m/s	: 9.6m : 9.6m : 1.1m/s	: 9.6m : 9.6m : 1.1m/s	-	High : Distance : Speed :	High : Distance : Speed :	High : Distance : Speed :	H : 9.6m D : 9.6m S : 1.1m/s	H : 9.6m D : 9.6m S : 1.1m/s	: 9.6m : 9.6m : 1.1m/s	: 9.6m : 9.6m : 1.1m/s
Intelligent flight mode						-	-	-	-	-	-			-	-

(c) Importance and user preference assessments: A survey was conducted to assess the importance and preference of the derived representative functions and interface elements, respectively. Individual subjects performed the assessment on a 5-point Likert scale, and the resulting average was used as a measure of importance. For assessment of interface element preference, similar elements were combined and the participants were asked to choose the most intuitive element. Its frequency was then extracted and analyzed.

(d) Competitive Benchmarking Chart: This chart was constructed based on the collected data. In a previous research [14], this was based on user requirements and functional matrix. Here it is analyzed using the representative function and interface element matrix. For interface element rating, considering the response of the total 50 people, if the total frequency of selecting a specific interface element is in the range 0-10, 11-20, 21-30, 31-40 and 41-50, the rating given is 1, 2, 3, 4 and 5, respectively.

4. **Results.** Table 2 shows the outcomes of Competitive Benchmarking Chart, and therefore highlights the importance of representative functions and preference of interface elements. For this research framework, application information is included at the top of the table (third row) to compare both hardware and software assessments. While DJI's Spark, Phantom 4 Pro, Inspire 2, and Mavic Pro used the DJI GO 4 app, SYMA's X25PRO and Z1 used the SYMA FLY app. Note that Typhoon H plus has confirmed that their drone is powered by hardware controller only with no associated applications.

From the Competitive Benchmarking Chart, it is easy to infer which drone has good interface element score for each representative function. For example, for the 'Return

TABLE 2. Competitive Benchmarking Chart based on UI score

	Company		DJI					Parrot			SYMA			Yuneec		Autel	
	Controller match status		O				O	O	O	O	O		O	O	-	O	O
	Software(APP) Information		DJI Go 4				Tello	Freeflight6	Freeflight Pro	Freeflight Mini	SYMA FLY		SYMA GO	Yuneec pilot	X	Autel explorer	X-star
#	Required Function	IMP	Spark	Phantom 4 Pro	Inspire 2	Mavic Pro	Tello	ANAFI	Bebop2	MAMBO	X25PRO	Z1	X22W	Mantis Q	Typhoon H plus	EVO	X-Star Premium
1	Return home points	4.4	***	***	***	***	_	**	**	_	***	***	***	***	**	*	*
2	Intelligent flight mode	4.7	**	**	**	**	****	_	_	_	_	_	_	****	****	_	_
3	General Settings	4.2	*	*	*	*	****	****	****	****	*	*	*	****	****	****	*
4	Remaining drone battery indicator	4.1	*	*	*	*	****	*	*	_	*	*	*	*	*	*	*
5	Flight Remote Display	4.4	**	**	**	**	**	**	**	_	***	***	***	**	**	*	*
6	Takeoff / landing	4.1	*	*	*	*	*	**	**	**	*	*	**	**	**	*	*
7	Camera / video conversion	4.1	*	*	*	*	*	***	_	_	*	*	_	**	*	**	_
8	Control Interface (Turn left)	4.2	*	*	*	*	*	*	*	*	**	**	**	**	_	*	*
9	Control Interface (Turn Right)	4.2	*	*	*	*	*	*	*	*	**	**	**	**	_	*	*
10	Control Interface (Rise)	4.2	*	*	*	*	*	*	*	*	*	*	*	*	_	**	**
11	Control Interface (Drop)	4.2	*	*	*	*	*	*	*	*	*	*	*	*	_	**	**
12	Control Interface (Move left)	4.2	**	**	**	**	***	*	*	*	***	***	**	**	_	***	***
13	Control Interface (Move Right)	4.2	**	**	**	**	***	*	*	*	***	***	**	**	_	***	***
14	Control Interface (Forward)	4.2	*	*	*	*	***	*	*	*	***	***	*	*	_	***	***
15	Control Interface (Backward)	4.2	*	*	*	*	***	*	*	*	***	***	*	*	_	***	***

TABLE 3. Application-specific UI score and price

Company	DJI					Parrot			SYMA			Yuneec		Autel	
Product	Spark	Phantom 4 Pro	Inspire 2	Mavic Pro	Tello	ANAFi	Bebop2	MAMBO	X25PRO	Z1	X22W	Mantis Q	Typhoon H plus	EVO	X-Star Premium
Avg. UI Score	5.993				7.4	6.173	5.353	3.967	8.173		6.22	8.567	4.327	7.84	6.453
Price($)	519	1,889	2,666	1628	149	598	264	134	190	80	80	420	1900	1,085	649

home points' function, DJI drone using DJI Go 4, SYMA drone using the SYMA GO, and the Mantis Q function of Yuneec drone using the Yuneec application have high interface element score. Note that the interface element score is defined as UI score here.

Table 3 presents the UI scores and price of various applications. Because the same application shares the same interface element, the UI score is the same even if the product is different. Application specific UI scores are weighted totals of interface element scores, which are related to the importance scores of representative functions. The results of this analysis show that the average UI score of Mantis Q, SYMA's X25PRO, and Z1 are the highest. Further, an additional price analysis was conducted to assess company market strategy. Drone prices were obtained from the Amazon sales price in 2019. We observe that DJI's Phantom 4 Pro, Inspire 2, Mavic Pro, and Yuneec's Typhoon H are sold at relatively high prices.

5. **Discussion.** To begin with, it is observed that the interface consistency between the physical controller and the application is poor, even for the same brand. As a result, UI scores for some brands are different among the sub-products. For future references, uniformity is required for symbol, and the high UI score is expected to be benchmarked. It is highly likely that symbols from Mantis Q, X25PRO, and Z1 can be referenced in this process, even if they are from third parties.

Since drones are relatively new products, better user interface quality is more appealing to the users. The one-dimensional concept of the KANO model can therefore be applied here. Of course, there may be a leap; but under the assumption that selling price is a consumer's preference, we can draw a one-dimensional line as shown in Figure 2. This

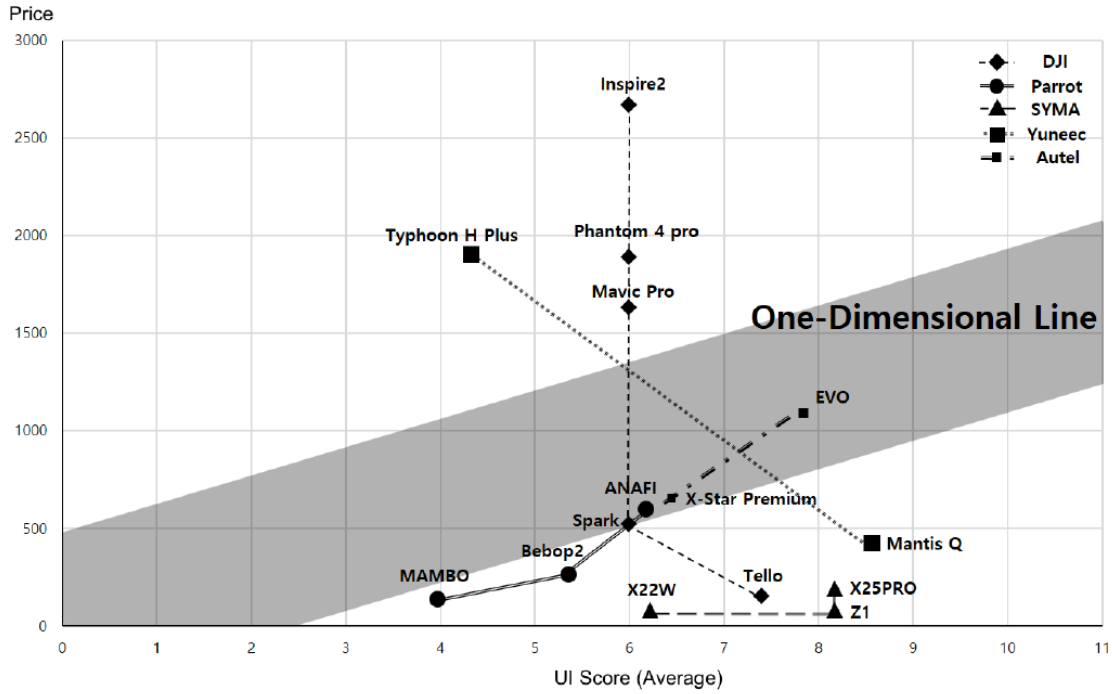

FIGURE 2. Company specific trade-off curve between price and UI score

has the following implications. DJI has several products, which are costlier than other brands; therefore, it has a confirmed high brand value. It may be noted that a product named Tello has invoked a low-price offensive strategy. Further, it is possible that SYMA uses this strategy against the relatively high UI score. This impact may be due to a low brand value. Finally, for Yuneec, Typhoon H plus is very expensive, even though it has a low UI score. This may be due to the use of advanced functions; however, user-oriented interface design is indispensable. On the contrary, this company's Mantis Q has a very high UI score, and is cheaper too.

6. **Conclusion.** We developed a novel methodology to evaluate the user interfaces for hybrid products and services. Drone, a representative IT product, was used as a prototype for this study. A total of 5 manufacturers, 15 products, and 10 applications were assessed. This is the best possible product line for applying this methodology in drones, as it includes multiple products in a single brand as well as products sharing several applications. We observed that the user interface scores were different in the same brand, and the comparative analysis advocated a direction of market strategy.

Future research scope may include assessment of product categories besides drones. Another prospect is to reassess drones, to measure the rate of change in interface assessment. This methodology may prove to be extremely beneficial in light of the fact that it can be applied in a variety of situations with hybrid products and services.

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