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ORIGINAL PAPER

Natural User Interface for color selection in conceptual design phase

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Abstract In most of the surrounding discrete products, style plays a very important role. Specifically, color has a great impact in the visual perception, and its meaning can vary depending on the context where the product is located. Anyway, there are not dedicated applications devoted to support designers during this activity of color selection in the conceptual stage of the product design process. In this way, this paper presents the development and evaluation of a software platform that allows the user to choose a scheme of colors of a product concept using a Natural User Interface (NUI) in a 3D scanned context. In addition, the NUI was validated and evaluated with a case study oriented to compare the scheme of colors, for a conceptual product, selected by product designers, an expert panel and the target user in order to prove that this interface can enhance the process of color selection during the concept stage of the product design process, with regards to a traditional selection process with images and user profile.

Keywords Color selection · Natural User Interface · Conceptual design · Virtual window

1 Introduction

According to French during the conceptual stage of the product design process, a statement of a problem is defined, generating a wide range of solutions in form of concepts which are evaluated in order to select one concept to be further developed in a product [1].

Pahl et al. define the conceptual design as a process where through the identification of the essential functionalities related to the solution of the problem, using the abstraction and combining working principles into a working structure, a basic solution path is laid down [2]. In this way, conceptual design specifies the principle of solution.

One of the main characteristics of the conceptual phase is that it is based on decision-making activities that are crucial for the final product success. These stages affect to a larger extent the quality, cost, time and success of a product in the market [3]. In addition, the cost of either fixing errors or making changes to a design escalates dramatically as the design advances in the product life cycle [4].

The first stages of the product development process have a high influence in the success of the product because important characteristics like its appearance, properties and functionality are defined [5]. Therefore, it is easier to make changes during early stages and making good decisions can save money and time [2]. Anyway, there are limited computational tools available to provide better support to the designer, especially at the earlier stages of the process [6].

On the other hand, the highly competitive market is obligating enterprises to develop products with a strong emphasis in the style and image perception [7]. Tsai et al. define style as a combination of form and color in the image or sensation of a product [8].

Also, color is a fundamental variable when a user decides whether (s)he likes a product or not. Besides, surrounding user's products have reached a mature phase and different available products do not vary much in functionality, therefore style plays a very important role in the purchase decision. It also has been demonstrated that color has a greater impact than form on consumers' perception [9]. Therefore, it is more

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effective and less resource consuming modifying a product's color that generating a variety of products with different forms [8].

1.1 Tools for color selection

In design as in other productive processes, the tools and techniques are determinant in the results since they directly influence the way the product itself is conceived. Thereby, the way in which products are conceived is largely influenced by the used tools [1]

However, several previous studies are related to support systems for the color selection based on Grey Theory [10], Harmony Theory [8] and the use of the Neuronal Network. These systems use a relatively small data base created from users' and designers' opinions [7]; but the product's context is not fully considered.

Further, Elliot and Maier presented the *Color-in-context Theory* where the main idea is that color carries different meanings in different contexts and, therefore, it has different implications for feelings, thoughts and actions in different contexts. Also, the context reflects and has the elements that show more information about the user that can be useful to the designer at the color selection activity. Therefore, context has an influence over the color decision [11].

When design tools used in the process are updated, new interactions are open, facilitating and increasing the possibility for the designer to make easy color selection. Further, Bowman et al. presented an overview of three-dimensional (3D) interaction and user interfaces and they have shown that a Natural User Interface (NUI) should be used when a replication of the real word is important and it is necessary to limit the degrees of freedom in order to guide user's input. Anyway, it was not stated whether a standard for 3D interfaces will be practical and how these techniques can affect the user's sense of presence [12].

1.2 Conceptual design stage in product design

A conceptual design stage review, for three different well-known methodologies, is presented here in order to contextualize and get the requirements needed to the development of the proposed interface [2–4].

In general the conceptual stage can be divided in three different steps:

(a) *Clarify the problem* Different activities in order to identify the problem and its boundaries, what the goal is and the different interactions between the elements with techniques such as functional structure.
(b) *Generation of concepts* This step could be divided in two sub-steps.
   - The search of a possible existing solution, both externally and internally. The external solutions refer to existing solutions such as patents and the internal solutions are generated by an analysis of the problem.
   - Combination of available solutions and configuration in several concepts.
(c) *Concept selection* Evaluation of the previously generated concepts against different criteria in different aspects, in order to determine the value of one solution with respect to an objective. Pugh proposes an extended list of 32 elements in different aspects such as performance, maintenance, shipping, product life, etc. [13].

1.3 Evaluation of aesthetics and color in conceptual products

The evaluation of a product involves a demonstration of the designer's work and the visualization should show that the design fits spatially and aesthetically into its environment [14]. Besides, product design evaluation is important to get feedback from the user's perception in different fields such as functional, aesthetical or usability and to make sure that the product characteristics meet the user's needs.

The aesthetics is characterized by the feelings of (dis)like based on a sensorial perception and it is just a part of the product experience levels. Understanding and emotional levels deal with human mind faculties [15]. It is also known that the designed things do not exist in the vacuum, instead they are in dynamic relationship with people, places and other things that carry personal, social and cultural connotations, and that experience changes over the time [16].

In addition, the evaluation of aesthetics does not often consider the context in which the product will be located and this can affect the way in which the user perceives the concept because it has been proved that color carries different meanings in different context and therefore, it has different implications for feelings, thoughts and actions in different contexts [11]. The context is full of information about the user, his or her preferences, products and colors. Also, people tend to surround themselves with artifacts that reflect their self-image (houses we live in, the cars, even dogs). Together all the pieces make up the visual image we project of ourselves [3].

Therefore, the elements to be considered in the evaluation of a product are: its concept, user and its context. These three elements are all related and influenced among them and they need to be considered when a product evaluation is performed, as their interaction defines how a product will fit in its life cycle.

1.4 Interactive design

The concept evaluation stage plays an important role because it is the filter that defines the main product concept that will continue the design process. In this stage several properties are evaluated regarding to industrial, ergonomic and aesthetic aspects, among others, and some of the properties such as aesthetics, appearance and finish require the interaction with the context in which the product will be located in order to obtain a full perception. This context reflects the user's self-image [3].

This project makes efforts in the ideal engineering support system to allow the user to feel and act over a virtual product as in the real life. It consists in guaranteeing the perceptual relations between the user and his/her future product through high realistic simulation [17].

In brief, this research is devoted to the development of a NUI to interact with virtual concepts in virtual contexts, simulating the scale and rotation of both context and product accordingly to the user position, and to allow the evaluation of their aesthetics, appearance and finish materials and to select a combination of colors. The proposed NUI allows to include the user into the context and to observe the interaction between them and how the product fits in its context. This allows the designer to make decisions based on the natural interaction of the product concept and the user context.

Next section describes the features of the NUI and the used strategy for its development. The NUI metaphor, its implementation and the whole system are described, explaining how the NUI interacts with the 3D modelling software and the different libraries. Section 3 presents the setup of the experiments to evaluate the functionality and applicability of the NUI, comparing two interfaces and two design case studies, which are presented in Sect. 4. The results are described in Sect. 5 and conclusions about the development, implementation and perception of the NUI are presented in Sect. 6 .

2 Proposal of NUI for color selection

The Natural User Interface (NUI) is described as an user interface that remains hidden and allows to quickly learn complex interaction. It lies in the created experiences in the use of the technologies, fosters better mirror human capacities, optimizes the path to apply expertise to given contexts and tasks and fulfills the user's needs. Further, the "Natural" aspect refers to the user's behaviour and feeling during the experience rather than the interface being product of an organic process [18].

In this way, main requirements for the NUI are:

- The interface requires an integration with the software used to visualize the concept as rendering software or 3D modelling software.
- The visual interaction with the context needs to be simulated.
- The color assignation to the parts of the concept must be integrated with the interface.
- The interface must be based in a real-life object interaction.

The used strategy is to implement a metaphor that guides the interaction between the software and the user. The interface locates the virtual camera available in most of the 3D software in the position of the user head.

Next, the proposed NUI and the whole system are described:

2.1 NUI description

The NUI reproduces the metaphor of seeing through a window (the screen of the computer) in order to present, to the user, the 3D virtual concept in its context. This strategy emulates the way the user interacts with things and objects in real life. Further, the interface positions the camera (location, rotation and scale) according to the user's head simulating the perspective as if the context and the concept were located behind the screen.

A web camera, positioned in the screen, was used to get the position of the user face and *Haar-like feature-based cascade classifiers*, which are an effective object detection method proposed by Paul Viola and Michael Jones [19], were implemented in the repository of algorithms of the Open Source Computer Vision Library (*OpenCV*).

The first step is to obtain the user head position, (x, y), in order to locate the virtual camera in the 3D software that will be placed in the same position that the head, as it is showed in figure 1. The distance between the virtual camera and the virtual concept, z, is the addition of the distance between the virtual camera and the screen, z_r, and the distance between the screen and the 3D virtual concept, z_c. This distance is calculated based on the diameter of the head, and for this setup a media of $H = 156.214$ mm has been used, based on an anthropometric study of people between 26 and 27 years of age [20].

OpenCV includes both a trainer and a detector, but for this case a pre-trained classifier included in the software has been used. Once the classifier is trained, it can be applied to a region of interest in an input image moving the search window across it, in order to search the face. When the face is found, the algorithm returns the position of the detected faces, where (x_h, y_h) is the top point of a rectangle that encloses the face, and the width and height, (w, h), of the rectangle [21].

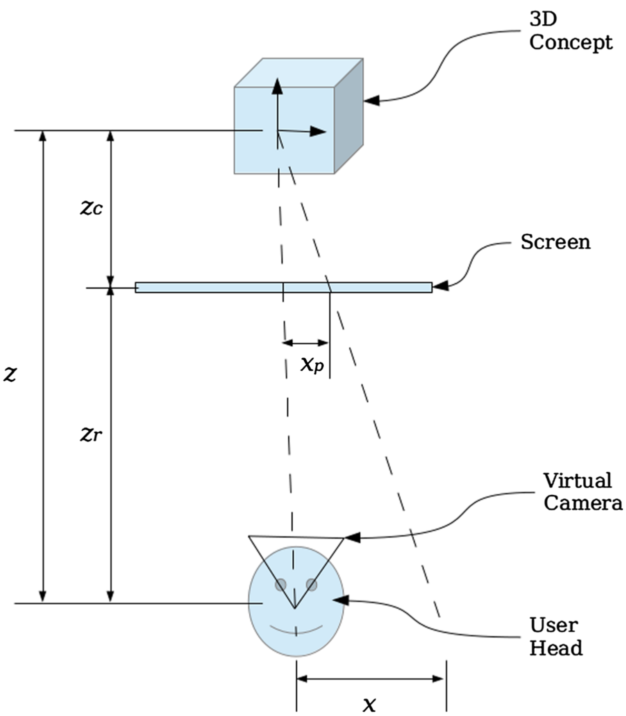

Fig. 1 Conceptual description of the system

The position of the projection of the user head into the screen, (x_p, y_p), is obtained from Eq. (1).

$$(x_p, y_p) = \left(\frac{x_h + w}{2}, \frac{y_h + h}{2}\right) \quad (1)$$

The returned values for each frame of the video are represented by Eq. (2):

$$P(t) = (x_p, y_p, h) \quad (2)$$

Using the similar triangles theorem the position of the virtual concept with respect to the screen can be derived from the Eq. (3):

$$(x, y) = \left(\frac{x_p \cdot (z_c + z_r)}{z_c}, \frac{y_p \cdot (z_c + z_r)}{z_c}\right) \quad (3)$$

The required variable is the position of the user head regarding the camera and the similar triangles theorem is applied in Eq. (4), where f is the focal length of the web camera:

$$z_r = \frac{H \cdot f - h \cdot f}{h} \quad (4)$$

In addition, the vector of the virtual camera normal is always pointing to the center of the 3D virtual concept. Thus, the rotation of the virtual camera is assigned by the position of both the virtual concept and the virtual camera.

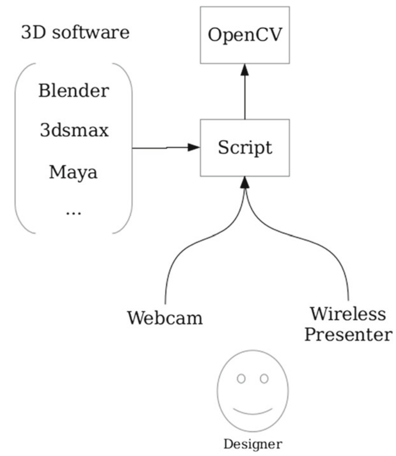

Fig. 2 System overview

2.2 System overview

The proposed system, as represented in Fig. 2, consists of a script in *Python*® language that works as a user interface allowing the user to control the 3D software with a web camera and a wireless presenter, used for additional tasks, such as changing color of the 3D virtual concept. The script uses *OpenCV*® library and can be used in others 3D software that allow to be extended using *Python* scripts, such as *Blender*®, *3DMax*® and *Maya*®.

The interface was developed in *Python 3.0* to be used with the 3D software *Blender*. *Python* is an interpreted, object oriented programming language, combining power and a very clear syntax. It has interfaces for many system calls and libraries and it is very common to be used as an extension language for applications that needs programmable interfaces, in this case *Blender*. In addition, it is portable an run under many Unix variants, Mac and MS-DOS systems [22].

The user runs the NUI script on *Blender*, a cross platform open source 3D animation suite. It completely supports the 3d pipeline including: modelling, rigging, animation and rendering. In addition, it allows to employ *Blender's API* for *Python* scripting in order to write personalized tools. It has an embedded *Python* interpreter that can run scripts, draws the user interface and accesses to some internal tools.

The script uses *OpenCV* that is an open source computer vision and machine learning software library, providing more than 2500 optimized algorithms which allow face detection and recognition and produce 3D point clouds [23]. Through *OpenCV* the video stream from the web camera is processed, and returns the position coordinates and the size of the head.

3 Experimental setup

In order to validate the functionality of the proposed NUI, two different case studies were elaborated based on two target

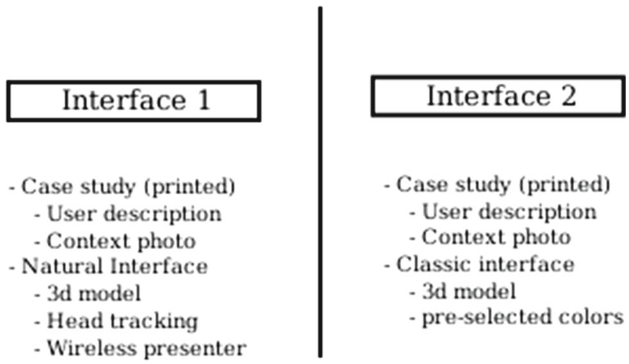

Fig. 3 Description of both interfaces for validation of the NUI

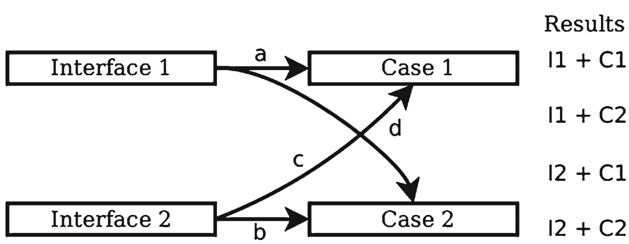

Fig. 4 Test work flow

users who proposed and classified the possible color combination for a desk lamp according to their preferences. For this activity, each target user employed the NUI and the 3D modelling software to preview the product colors. Besides the functionality validation, this experiment has been designed for a second objective, which will not be considered in this document, related to the identification of correlation between the selection of the color of a product and the colors of the context where the product is going to be used or located. In this way, the experiment has been implemented with three different roles of users of the interfaces, but only "designers" were asked to evaluate the interaction with the NUI.

For the color selection of the conceptual product, two different interfaces were implemented. "Interface 1" is the proposed NUI and "Interface 2" is the "traditional tool" to define the color of a concept during the fuzzy phase in which the designer uses a 3D virtual model and a user description. Both interfaces are presented in Fig. 3.

The case studies were presented to the same designer using both interfaces (NUI and traditional method) in order to compare the ease of use and the interaction between the context and the product. Besides, the use of the interfaces was interspersed across the test as shown in Fig. 4.

The experiment evaluates the process of color selection using (and not) the NUI by three different roles: target user, designers and expert panel.

The experiment with designers was performed in a group of 18 product design engineers (73 % were professionals and 27 % were undergraduate students). Besides, the group had an average designing experience of 5 years (minimum 2 years, maximum 10 years).

The expert panel was composed by five professors of different areas of the undergraduate program of Product Design Engineering, at *EAFIT University-Colombia*. The group was constituted by an industrial designer and M.B.A, an industrial designer specialized in strategic design and innovation, an industrial designer, Master in product design and innovation and PhD in mechanical engineering, an industrial designer,and a production engineer and Master in materials.

The experiment was designed in order to evaluate, in the first instance, the user interaction with the interface, and to identify the influence of the context in the perception and selection of the color of a conceptual product. This paper is focused on the first objective.

Next, both interfaces are described in detail.

3.1 Natural User Interface (NUI)

This widely accessible interface is intended to achieve a natural interaction, between the user and the representation tool, for the color selection of a design proposal. The software component relies on free open source software and the only hardware required is a web camera, a wireless presenter and Internet access.

The NUI can be mapped to the metaphor of seeing through a window. The interface allows to all the elements (context elements and the virtual concept) to be positioned accordingly to the user's face position to achieve a realistic perspective of the context previously modeled.

The usage of the interface can be divided in two stages:

1. *3D stage* The following steps are carried out:
   (a) 3D conceptual modelling of the product
   (b) 3D scanning, virtual modelling and rendering of the context with its real materials and colors.
2. *Color selection* The 3D virtual models of the components of the product are rendered with the different colors which are under evaluation. Context and concept are displayed in real time according to the user's head position. The colors of the virtual concept can be changed using the wireless presenter. *Blender* was used for the 3D modelling of the concept and a regular digital camera was used for the 3D scanning of the context.

Three different methods for the scanning of the context were evaluated:

(a) *Image projection* (Mirror-ball or box mapping) can be easily carried out and it successfully creates a fake perception of a surrounding context. It is more adequate for steady renders because all the elements of the context

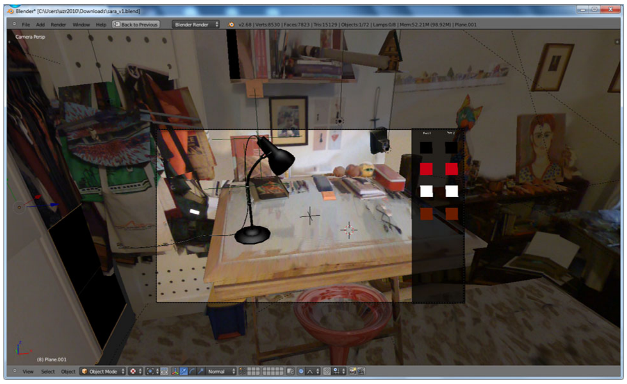

Fig. 5 Blender script for color selection screen shot

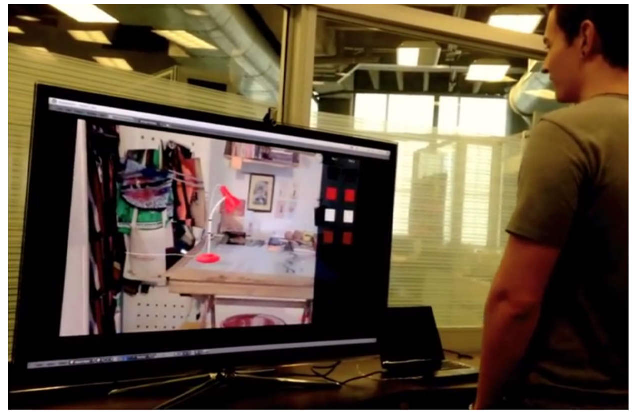

Fig. 6 Natural user interaction in color selection

are projected at the same distance on a basic geometry (sphere or cube), so when the user moves, it becomes evident that the context is a projection.

(b) *Photogrammetry* Allows interacting with the elements of the context and correctly displaying their geometries and textures giving more sense of depth, but it is time consuming. There are many free on line service alternatives that allow uploading a sequence of photos and getting those images processed in their server returning a 3D model almost ready to be used. However, objects that have mirror-like or glossy materials cannot be scanned with this technique. So, it is not suitable for the presented case study.

(c) *Camera mapping* Allows a non-complex textured 3D model of the context (based on primitive geometries) that is based on the real elements and measurements of the context and has more control.

Regarding the color selection stage, the context and the model were displayed in *Blender* and the following two functions were used in its game module:

(a) *Camera positioning* It is achieved using a *Haar Cascade* and an *OpenCV* object detector, as it was explained in Sect. 2.1. The interaction is limited to the movement of the user's head as if (s)he was behind the screen. A screen shot of the application can be seen in Fig. 5.

(b) *Color loop function* The different colors of the selected parts are set as a list of RGB tuples. Therefore, when the user presses one button of the wireless presenter the current color changes to the next RGB tuple.

The experimental setup is presented in Fig. 6 where the user's context has been modelled and the desk lamp is the conceptual product to be evaluated in different available colors.

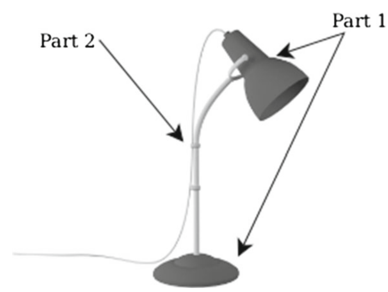

Fig. 7 Virtual 3D model of the desk lamp for the case study

3.2 Classic tool interaction

For this activity of the case study, only the modelling software *Blender* has been used and the possible colors in the different layers of the 3D view have been pre-configured. Anyway, any 3D modelling software could be used to represent an object and to change its color.

This software allows the user to navigate through the 3D virtual model, changing the position of the camera with simple mouse commands. Also, in different consecutive layers, the same 3D model with a different color configuration was placed allowing the user to simply change the pre-configured color schemes.

4 Case study

In order to evaluate the functionality of the NUI, two different case studies were proposed to a group of designers. Each case considered the definition of five combinations of colors for a desk lamp, presented in Fig. 7, that suit better for the proposed target user in a specific context. The desk lamp had two group of parts with different colors to be combined.

Additionally, each case study had a different target user chosen with the intention to have an opposite style. The first one is a man (case one) and the second one is a woman

Fig. 8 User's contexts. **a** Man's context and **b** Woman's context

Table 1 Experiment color notation

Case 1-target user 1		Case 2-target user 2	
Code	RGB	Code	RGB
n	0, 0, 0	n	0, 0, 0
b	255, 255, 255	b	255, 255, 255
a	0, 71, 255	r	197, 0, 11
v	92, 133, 38	c	76, 25, 0

(case two). Both target users are 22 years old and they are university students. For the man's context, the cold colors prevail, the elements of the context are well-arranged and the shapes tend to be more linear, in opposite to the woman's context that presents warm colors and a cluttered context. Both context are presented in Fig. 8.

This setup is proposed to avoid that color, gender and likes influence in the software usage perception and also to analyze if there is any influence in the color selection task and the designer's affinity. In addition, each target user was involved in the process of selection of four colors, as it is shown in Table 1, making different combinations and arranging them from the option that (s)he likes the most to the one that (s)he likes the least. Each letter in the "code" column represents a color in the RGB color model.

Also, a description of the target user was printed and presented to the designer for each case. This brief contained the user profile, favorite colors, movies, places, hobbies, brands, and a photo of the context where the lamp was going to be located.

Three different users were considered in the experiment:

1. *Target user* (S)he is the product buyer and user, without 3D modelling experience. Different colors based on his or her style were proposed to the user and (s)he evaluated and classified the possible color combinations for the desk lamp, using the NUI.
2. *Designers* The group is composed by product design engineers. Each designer was asked to determine five color combinations that suit better to the given user description, in both case studies. They used the NUI for one case and the classic tool for the other one. After completing the test, they answered what they thought about the software interaction, whether the software made easier the color selection and how sure they felt about the selection of the color combination with the interface.
3. *Expert panel* The group is composed by professors of different technical areas. They had access to the user information and determined five combinations and arranged them from the one that suits better to the user description to the one that suits the worse, using the NUI.

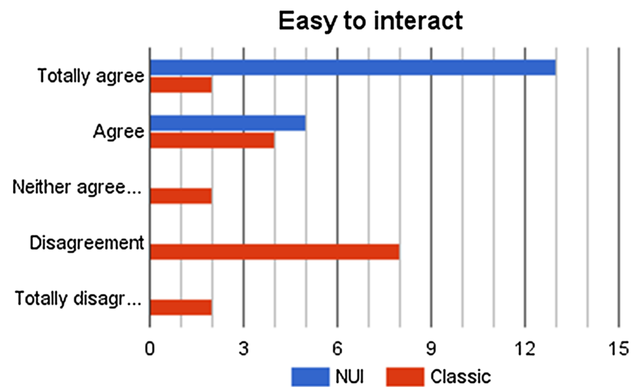

Fig. 9 Easiness during interaction with both interfaces

5 Results and discussion

In order to analyze the interaction with both interfaces, the 18 designers were recorded interacting with the software and some question about the interaction were posed. The test was performed on a laptop in a work ambient and there was no control over ambient stimulus. It is important to notice that there was no time limit and that either the emotional state or design skills of each designer were not under control.

Accordingly to Bowman et al., it is required to limit the degrees of freedom for the user input [12]. This was implemented by linking the camera rotation to always be pointing to the concept as it is explained in Sect. 2.1.

Regarding to the interaction with the NUI, 100 % of the users were totally or simply agree with the easy interaction with the interface, whereas with the interaction with the classic interface the opinions were more dispersed and 55 % of the users considered this interface difficult to interact with. These results are presented in Fig. 9

Regarding to the ability to make easy the color selection during the decision making activity, 94 % of the designers identified this advantage with the NUI, but, in general, both the classic interface and the NUI facilitate the color selection with a totally or simply agreement. These results are presented in Fig. 10.

Regarding to the confidence that the designer feels about the color selected and the fidelity of both interfaces, both

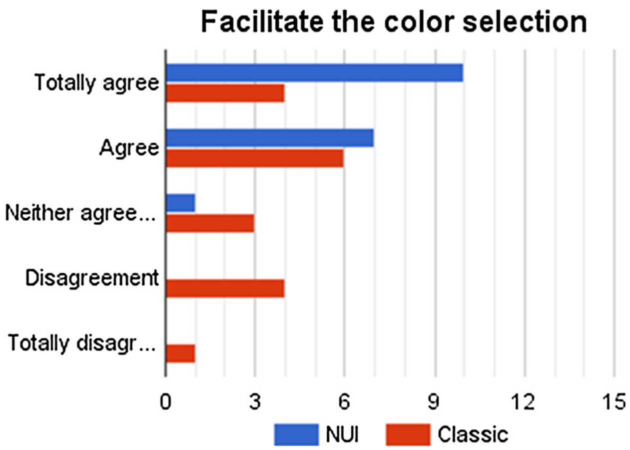

Fig. 10 Facilitation of the color selection

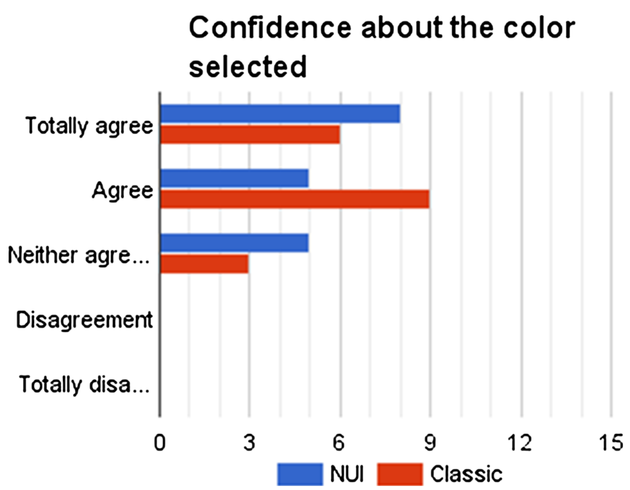

Fig. 11 Confidence of the color selection

were evaluated as valid tools to select correct colors (agree and totally agree) with a slightly advantage of the classic interface over the NUI. These results are presented in Fig. 11.

One of the most expressed feedback by the users was to minimize the vibration of the camera. This is generated by the face detector and it can be solved applying a moving average value.

6 Conclusions

- A NUI has been developed with open source software and easy available hardware in order to allow designers to interact with virtual concepts in virtual contexts and to evaluate and select different color configurations at early stages of the design process.
- The NUI allows a natural interaction between the user's context and the product's concept, enabling the designer to evaluate such interaction, through a computational tool resembling a virtual window.
- Even if the proposed NUI can be implemented in any stage of the design process, the selection of the color is an activity proper of the conceptual stage and this interface has been designed according to the requirements for decision making support.
- It is observed that classical tools used in the evaluation of concepts do not allow a full interaction with the user and the context, which prevents the incorporation of this interaction in the evaluation in early stages of the product development.
- The proposed NUI provides an easy interaction with the 3D virtual model of the context and of the conceptual product allowing the user to focus in the color selection activity instead of the interaction with the software.
- The proposed NUI can shorten the gap of training to use a 3D visualization software and allows the final user to take advantage of the use of this kind of software.
- The proposed NUI facilitates the color selection task compared to the classic interface, but regarding to the designer confidence both interfaces have a positive influence.

References

1. French, M.J., Council, D.: Conceptual design for engineers. Springer, Berlin, Heidelberg, New York, Tokyo (1985)
2. Pahl, G., Beitz, W., Feldhusen, J., Grote, K.H.: Engineering design: a systematic approach, vol. 157. Springer, London (2007)
3. Baxter, M.: Product Design. Chapman & Hall, London (1995)
4. Eppinger, S.D., Ulrich, K.T.: Product design and development. McGraw-Hill, New York (1995)
5. Ponn, J., Lindemann, U., Diehl, H., Müller, F.: Sketching in early conceptual phases of product design: guidelines and tools. In: EUROGRAPHICS Workshop on Sketch-Based Interfaces and Modeling (Citeseer, 2004), pp. 27–33 (2004)
6. Ye, J., Campbell, R., Page, T., Badni, K.: An investigation into the implementation of virtual reality technologies in support of conceptual design. Des. Stud. **27**(1), 77 (2006)
7. Tsai, H.C., Hsiao, S.W., Hung, F.K.: An image evaluation approach for parameter-based product form and color design. Comput. Aided Des. **38**(2), 157 (2006)
8. Tsai, H.C., Hung, C.Y., Hung, F.K.: Computer aided product color design with artificial intelligence. Comput. Aided Des. Appl. **4**(1–4), 557 (2007)
9. Lai, H.H., Lin, Y.C., Yeh, C.H., Wei, C.H.: User-oriented design for the optimal combination on product design. Int. J. Prod. Econ. **100**(2), 253 (2006)
10. Hsiao, S.W., Tsai, H.C.: Use of gray system theory in product-color planning. Color Res. Appl. **29**(3), 222 (2004)
11. Elliot, A., Maier, M.A.: Color-in-context theory. Adv. Exp. Soc. Psychol. **45**, 61 (2012)
12. Bowman, D.A., Kruijff, E., LaViola Jr, J.J., Poupyrev, I.: An introduction to 3-D user interface design. Presence Teleoper. Virtual Environ. **10**(1), 96 (2001)

13. Pugh, S., Clausing, D.: Creating Innovtive Products Using Total Design: The Living Legacy of Stuart Pugh. Addison-Wesley Longman Publishing Co., Inc, Boston (1996)
14. Ahlers, K.H., Kramer, A., Breen, D.E., Chevalier, P.Y., Crampton, C., Rose, E., Tuceryan, M., Whitaker, R.T., Greer, D.: Distributed augmented reality for collaborative design applications, In: Computer Graphics Forum, vol. 14, pp. 3–14. Wiley Online Library (1995). doi:10.1111/j.1467-8659.1995.cgf143_0003.x
15. Hekkert, P.: Design aesthetics: principles of pleasure in design. Psychol. Sci. **48**(2), 157 (2006)
16. Green, W.S.: Pleasure with products: beyond usability. Taylor & Francis Inc, London (2003)
17. Fischer, X., Coutellier, D.: The Interaction: a New Way of Designing. In: Research in Interactive Design, pp. 1–15. Springer, Paris (2006). doi:10.1007/978-2-287-48370-7_1
18. Wigdor, D., Wixon, D.: Brave NUI world: designing natural user interfaces for touch and gesture. Elsevier, Amsterdam (2011)
19. Viola, P., Jones, M.: Rapid object detection using a boosted cascade of simple features. In: Computer Vision and Pattern Recognition, 2001. CVPR 2001. In: Proceedings of the 2001 IEEE Computer Society Conference on (IEEE, 2001), vol. 1, pp. I–511 (2001)
20. Díaz-García, J., González-Zapata, L., Estrada-Restrepo, A.: Comparación entre variables antropométricas auto-reportadas y mediciones reales. Arch. Latinoam Nutr. **62**(2), 112 (2012)
21. OpenCV: Cascade classification. http://docs.opencv.org/modules/objdetect/doc/cascade_classification.html (2014). Accessed 18 June 2014
22. Python Software Foundation: General python faq. https://docs.python.org/2/faq/general.html#what-is-python (2014). Accessed 27 May 2014
23. Itseez: About opencv. http://opencv.org/about.html (2014). Accessed 11 June 2014