A smart mockup for an innovative interior yacht design approach

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Abstract. The design of the environment of a yacht or a ship must consider, among the many variables, the guest's experience and focus on its optimization; this means observing the modalities of interaction with the space and the objects that occupy it, acquiring the necessary information and, when possible, building a model capable of predicting, within a reasonable limit, the modalities of the interaction of different users.An intelligent mock-up is a structure designed to monitor the user experience through a network of sensors integrated into the environment that reproduces the space to be designed. It also introduces the furniture elements and whatever else characterizes it in reality.A dense network of optical, acoustic and piezoelectric sensors can return valuable information concerning both the visitor's interactions with the surrounding space and the perception of the environment itself by the occupants.One of the central elements is represented by a network of high-resolution video cameras, which acquires, among other variables, the pupil diameter (mydriasis is, in fact, and some precise circumstances, a critical neuro-cognitive indicator) of the visitor by including it in a data set that, as a whole, contributes to the definition of a model of interaction between visitor and environment, built on a neuro-scientific basis.Once validated, the model data can represent an essential aid for designing any interior space on ships and yachts without excluding different environments, smaller or located in extreme contexts..

Keywords. Yacht design, smart mockup

1. Introduction

A sailing or motor yacht is a complex piece of equipment that has to be able to function effectively and safely in an environment that is hostile both in terms of the conditions and the corrosive damage that can be done to machinery in all that salty air. According to Umberto Felci, a well-known yacht designer: "The sailboat's interior is something particularly fascinating. The project changed when we decided that a sailing boat could also be used as a living space. Interior design external functionalities must begin to dialogue with internal needs. The hull no longer performs only hydrodynamic functions, which are already quite complex but becomes a container: a "shell" needed to create spaces that will become vital and almost domestic. In a way, a boat without the possibility of being lived in is like an unfinished work of art. After all these years spent balancing all these elements in a unique project, I must say that it was fascinating to have to add these additional functions of "home" to the problems of the sailing boat, understood as a "means of transport" or even a "racehorse". Not an easy task because expectations are different for everyone. So those who love sailing tend not to be willing to give up anything that might have an external function, or affect absolute performance, to give the boat a chance to be experienced differently" [1]. Interior design development is a complex phase. The customer can be a stimulus towards the search for the unprecedented and the next step, but it can also become a limit to success and coherence. When the client decides to entrust us with his dream and to let us help him realize it, we must be able to understand him and take advantage of the opportunity to create something great. Like every other aspect of the design, even the yacht's interior is articulated in a spiral of passages that are repeatedly retraced based on the information gradually acquired. This research aims to lay the conceptual foundations for an innovative approach to interior design based on the use of new technologies that allow the rapid quantification of many variables.

2. Smart mockup

Unlike industrial design, naval construction always suffered the impossibility of realizing prototypes, finished and functional. Because of the size of a ship and the few units typically built, we may analogize construction to craftsmanship. A craftsman's number one creation is launched as a functioning exemplar. This determines manifold interventions to modify and correct design, construction, or assembly errors in a testing phase. Mockup models are used, providing at least part of the construction functionality to enable testing of a design and correction of errors in a pre-construction phase. Mockup models simulate a vessel's navigating bridge, its interior décor and exterior finishes, and part of its facilities and equipment. In addition to providing scale or full-sized design replicas, we use mockups to test the ergonomics, dimensions, and usability and acquire users' feedback regarding environmental well-being levels.

Simulation creates a desired set of physical and operational conditions in a controlled process or setting through graphic and mental images, technical assumptions, and direct experience. During planning and design, simulation helps answer some basic questions about design problems: Who is involved? What activities take place? How will the "designed" product or environment be used? What conditions or external forces act upon the proposed situation or outcome? As an anticipatory activity, simulation allows designers to observe and experience the proposed system in operation, facilitating problem definition and eventually permitting testing of all aspects of the designed system. A smart mockup is defined as a 1:1 scale representation of artificial habitat for this work. The interior volumes are made of smart materials and structures that can sense humans' interactions (via a network of distributed sensors) and adapt their internal characteristics (via a network of distributed actuators) to maximize functionality and comfort by using an elaboration unit [2]. The Smart Mockups can track the single user experience to optimize some a priori defined parameters: this is possible using an internal network of interconnected sensors that communicate with an elaboration unit that analyzes and stores the user's information. The smart mockups concept is placed between the 3D simulation and the realization of the prototype, in the same position as the tactile, haptic interface proposed above. Nevertheless, differently from other solutions, it can physically change its configuration without the necessity of re-building a new prototype. The innovative aspect of this research is represented by the application of machine learning techniques to interior design. Thanks to the presence of sensors inside the smart mockup, in the course of his experience as a user, each user is monitored according to specific parameters that constitute the elements of a state vector. The purpose of applying unsupervised classification techniques is to determine whether or not there are distinct classes of users based on the different combinations of the state vector.

3. Modelling user's behaviour using machine learning

The purpose of machine learning is to learn from the data. Many studies have made machines learn by themselves without being explicitly programmed. Many mathematicians and programmers apply several approaches to solve this problem with massive data sets. Machine Learning relies on different algorithms to solve data problems. However, data scientists like to point out that there "s no single one-size-fits-all type of algorithm is best to solve a problem. Instead, the algorithm employed depends on the problem that has to be solved, the number of variables, and the kind of model that best suits it. In the context of this paper, the aim is to develop a model of user behaviour to build a valuable tool for an interior yacht designer.

Unsupervised learning

These methods are called unsupervised learning because, unlike supervised learning, there are no correct answers and there is no supervisor [3].Algorithms discover themselves in the presence of an interesting structure in the data. The unsupervised learning algorithms learn a few features from the data. When new data is introduced, it uses the previously learned features to recognize the data class. It is mainly used for clustering and feature reduction. The principal component analysis is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into values of linearly uncorrelated variables called principal components. The data dimension is reduced to make the computations faster and easier. It explains the variance-covariance structure of a set of variables through linear combinations. It is often used as a dimensionality reduction technique. K-means is one of the simplest unsupervised learning algorithms that solve the well-known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters. The main idea is to define k centres, one for each cluster. These centres should be placed cunningly because different location causes different result. So, the better choice is to place them far away from each other. The next step is to take each point belonging to a given data set and associate it with the nearest centre. When no point is pending, the first step is completed, and an early group age is done. Finally, we need to re-calculate k new centroids as the barycenter of the clusters resulting from the previous step [4][5][6]. In the next paragraph, the variables used to define the status vector for each user of the mockup will be highlighted.

4. Psycho-anthropological considerations

Recent neuroscientific researches confirm the ancient notion that human mental processes are the psychic expression of body functioning. In fact, human existence is an embodiment of the adaptive processes of our organism in relation to the environmental challenges to which we are responding proactively and reactively [7].
From this viewpoint, it is possible to identify and measure several neurophysiological, postural and relational parameter aspects activated in human behaviour and achieve a broader classification of typology classes of human attitudes related to environmental stimuli.

Neurophysiological indicators

The neurophysiological factors that can be taken into consideration in this type of research are essentially two, i. e., body temperature and pupillary response. The deviation from the standard of these two parameters indicates the presence of a mental and behavioural adjustment response to the external environment in neuro-cognitive and experiential terms.

Motion/speed parameters of the body

The functioning of human consciousness is connected to the activation of complex cognitive processes, even though numerous scientific researches investigating consciousness suggest different interpretations of its brain emergence. A function that evidences the functioning of a state/tract of consciousness is attention, i.e. the voluntary focusing on something external or internal to oneself. A bodily symptom of this activation is the slowing down of movement, both in the arms and legs, so that one's vision can be turned slowly to the surrounding environment in order to achieve a cognitive consideration of what one is observing. The same attitude also occurs when focusing on one's inner self. With this in mind, it may be important to record the various gestures and speeds of the mockup users.

Postural parameters in the seated position

Equally important will be the recording/observation of sitting posture. According to past and recent research on non-verbal communication, such "behaviour" can indicate one's emotional-cognitive well-being, such as a willingness to observe/focus on areas of the environment and reveal a different level of "perceived general ease" within the space. The pattern of the look, the position of the back, together with the position of the upper and lower limbs, the speed/slowness of the eye movements and the direction of the gaze can disclose inner mental attitudes of well-being and calmness or discomfort and unease.

Parameters on relations with environmental spatial objects/portions

According to the Social Psychology perspective, every human being, in the dynamism of his individual existence and therefore of his evolution, can be an acting subject or an acted subject. In the first situation, we are talking about an individual who can carry out his desires and existential projects, trying to adapt them to the surrounding environment [8]. In the second one, we are facing an individual who is submitted both to the environment he is in and to the behaviour of other people.

We could otherwise qualify the situation as active in the first case and passive in the second. There is no clear dividing line between the two behaviour types because, in everyday existence, it is also necessary to be flexible according to the circumstances in which we find ourselves. Consequently, the progression from an acting dimension to an acted dimension is vital for the positive integration with environmental situations that each individual has to accomplish. From this point of view, for the subject of this study, the relationship that each individual establishes with objects within the environment in which he or she acts can be considered as the expression of his or her singular way of being perceived as more or less integrated, i.e. inserted, and therefore at ease, in a given environment. Touching or not touching objects, handling the elements (micro and macro architectures) that are part of an environment, possibly relocating these objects, establishing a spatial relationship with them (which is reflected in the distance that is generated between one's body and the objects) are all indicators of one's way of feeling included or not within a space that is accepting rather than oppressive.

Therefore, recording these behavioural, spatial and temporal attitudes (temporal because when we are comfortable, we tend to stay longer in a space/environment) can facilitate a post-assessment of the types of people who manage to interpret the studied environment positively or negatively [9].

5. Conclusions and future works

Based on what has been highlighted in this research, it is possible to identify a significant set of variables capable of defining a user's status during his use of the smart mockup.
A critical aspect, which strongly influenced the choice of the parameters to be monitored, was the possibility of carrying out measurements remotely. That is, without the need for any interaction with the user.
This choice was determined by the fact that any activity outside of what is generally expected in the use of the internal space of a yacht would have strongly influenced the behaviour and consequently distorted the data.
Further steps in defining the solution proposed here will consist of identifying the specifications for constructing a demonstrator. Furthermore, great attention will be paid to the choice of both the sensors, their spatial arrangement, and the appropriate algorithm (among those proposed) to carry out the unsupervised classification.

Authors' contribution

Within the work here presented MIZ wrote Sect. 1 Introduction and Sect. 2 Smart mockup; PG wrote Sect. 2 Smart mockup, Sect. 3 Modelling user's behaviour using machine learning and Sect. 5 Conclusions and future works; AB wrote Sect. 4 Psycho-anthropological considerations

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