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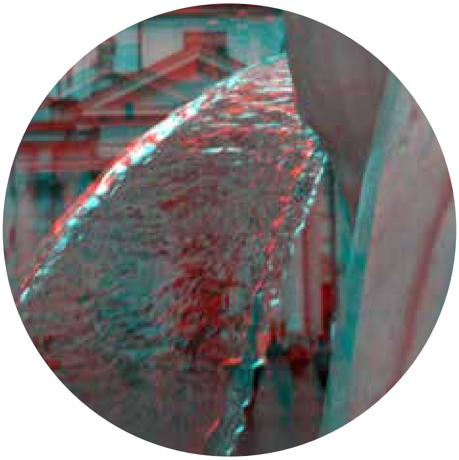

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A participated parametric design experience on humanoid robotics

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Abstract | The project hereby presented illustrates the case study of a participated parametric design workshop, where the object is a hacked version of Poppy, an open source 3D printable humanoid robot developed by Matthieu Lapeyre. Poppy is used by a large community of researches whose focus is mainly on engineering and IT aspects of the platform development. Our activity, held in a larger dissemination event, was aimed instead at collecting data regarding users' perception of a companion robot, caregiver robot or evil robot. Our goal is to define aesthetic principles that influence users' appreciation and affection towards a humanoid robot. A parametric definition developed with Grasshopper 3D, easily editable thanks to a simple and intuitive interface, was used as a tool to involve users in a co-design activity which results are analyzed and presented in the following contribution.

KEYWORDS | HUMANOID ROBOTICS, PARAMETRIC DESIGN, PARTICIPATORY DESIGN, 3DPRINTING, OPEN SOURCE

1. Introduction

We are living in the era of bespoke products and personalization. This generic trend has evolved and become massive in most industries, supported by several technical developments in the world of design, such as the spread of open source tools for digital design, the development of rapid prototyping technologies and the emergence of the parametric approach in several areas of the world of the project (Manzini, 2015).

In particular, the practise of parametric design, described by the architect L. Moretti as "the relations between the dimensions dependent upon various parameters" (Bucci & Mulazzani, 2006), has spread from the architecture world to product design as new and more effective tools have been developed. Nowadays visual editors and programming tools are easier and easier to access, implement and learn; they allow designers to draw with algorithms, which can be defined as procedures that perform particular tasks through finite lists of well-defined instructions and inputs (Tedeschi, 2014).

If writing algorithms and designing with parametric tools remain prerogatives of the developer or the designer, these instruments can easily be used in participatory design experiences.
Participatory design has its roots in Scandinavian culture; the first co-design techniques have been developed there in the 1970s, but are taking upon themselves new meanings and definitions through the spreading of mass customisation in contemporary industry and the following growth of configuration tools designed to be used by end users who can thus make - usually small - design choices on the products that they are going to buy (Ciuccarelli, 2008).

Moreover, co-design techniques are very useful in the User-Centered Design process (Falcinelli, 2011). This essential practice of design is widely accepted and frequently used these days, especially in technological areas due to the fact that most likely a high-tech product, system or service will interact actively with users for which it is intended (Rizzo, 2009). Research in this field is even more important if we think of users that may not be used to interact with technological products, as in the case of elderly or people with disabilities. Speaking of interaction with technological products, it can be assumed that humanoid robots could provide the most complete experience in this respect. Therefore, it is of great importance to investigate people perception of those products, especially by weak users.

2. User Centred Robotic Design

The rapid technological growth that we are facing nowadays has highlighted issues about human-computer interaction, specifically with reference to the scope of robotics. Such dynamics open up new challenges for UX designers (Gamberini et al., 2012). While in the past the robotics scope was mainly involved in design industrial machines, in recent years we have witnessed an increasing number of social robots. The latter are able to interact, sometimes having complex relations, with human beings and other machines. They are able to learn from the environment in which they are located as from the interactions with users and to develop a decision-making autonomy. The problems that arise within this context are still addressed without a multidisciplinary approach that would be necessary (Casiddu & Micheli, 2011).

Designing a social humanoid robot is not just the development of a consumer product as a household appliance and is not just the engineering of a body to a vocal assistance. Is a discipline that is located somewhere between the two previous ones: to create a physically tangible automaton, more or less human-like, able to act and react with a decision-making autonomy and capable to arouse complex emotions. This is not just about dealing with technical issues, but also taking into account the psychological side, considering the legal liability, evaluating social dynamics, economic viability and environmental impact. Therefore, it is necessary to place the individual at the center of the design process in order to directing research and activity to design an acceptable and accepted user experience of the interaction. Only then not just the shape but also the behaviour of social robots will be human-like and the technology will fit users' needs.

3. Poppy, a case study

The project hereby presented illustrates the case study of a participated parametric design workshop, where the object is a humanoid robot.

Our aim is to analyze the morphological aspects of humanoid robots and the users' perception regarding them. In order to do that, we planned an activity that would positively involve a wide audience in making design choices on a humanoid robot; in particular we worked on editing the 3D models of Poppy, which is fully available online on an open source platform developed by Matthieu Lapeyre in 2012, for his PhD thesis (Lapeyre et al., 2014).

Poppy is an 83 cm tall robot having 25 degrees of freedom and weighing 3.5 kg; it is fully 3D printable and hackable and it has a very active community surrounding the project, including universities, research institutions and private entities. Most of the research surrounding Poppy is focused on developing its engineering and IT aspects, but that was not our focus for this project. In fact, the mechanical and electronic parts remain the same, and the IT development has not been taken into consideration.

Instead, we re-designed the 3D model of Poppy's limbs using Grasshopper, a well-known visual programming language and environment that runs within the Rhinoceros 3D CAD application.

We used texture mapping to chart arms and legs and edit them using six different shapes with a varying design and degree of hollowness; in general, the editable parameters in our model were the following:

- colour of the head
- shape of the eyes projected on the incorporated screen
- chest, shoulder and hip colours
- type and density of the texture and colour of the upper arm
- type and density of the texture and colour of the forearm
- hand and foot colours

- type and density of the texture and colour of the thigh
- type and density of the texture and colour of the shin

As the joints of arms and legs remained the same of the original model designed by Lapeyre, we created a parametric system that allows to change every single limb of the robot without affecting its functionality and stability. In theory every user can now design his unique companion robot, according to his needs and tastes.

4. Method

In this section it is described our approach to the activity, the setting and the user experience.

The workshop took place during Rome Maker Faire 2019 for three days. The audience varied from families to technology amateurs and students. We used the tool of the survey to collect data about the visitors' age, gender and education level; this way we can paint a clear picture of the results we collected. At the end of the survey we would send the image of the designed robot to the participant's email. However, the survey took some time to be filled and many visitors, even though they found our activity engaging, decided not to complete it. In the end we collected 71 different designs for our robot; most of the participants were very young, between 5 and 12 years old.

The setting of our activity was very simple. We had a stand with a few tables where we placed some FDM printers, that we used to print in real time the pieces we needed to build our Poppy. While some of us worked on assembling and printing the robot, others were greeting the visitors and guiding them through the activity.

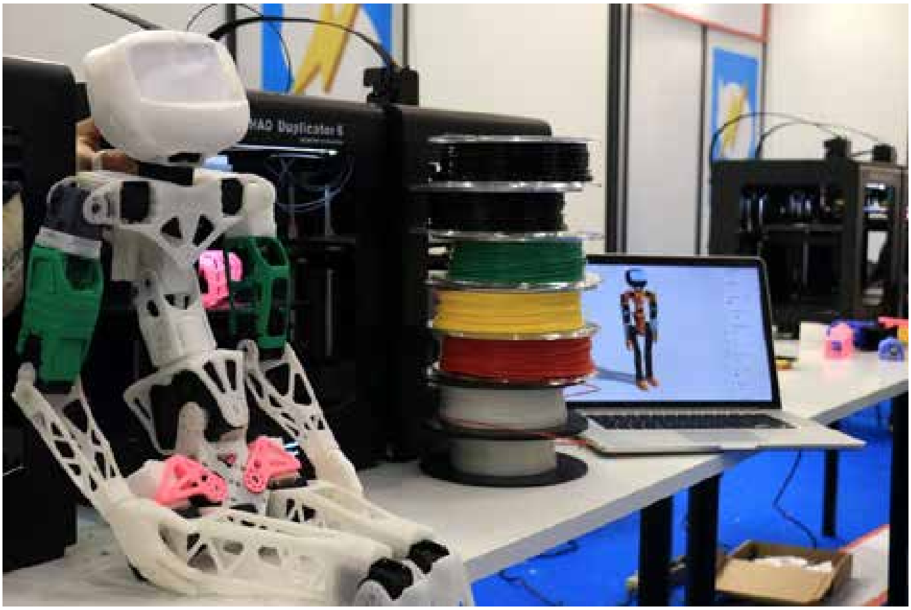

Figure 1. Set-up at Rome Maker Faire 2019.

Before starting to design their robot, participants were asked to choose between three different scenarios: they could design a caregiver robot, a toy robot for their kids to play with or an evil one. This choice would influence all the consequent ones and already represents an interesting term of comparison: we will discuss the results in detail in the following section.

The parametric model was easily editable thanks to the simple and intuitive interface of Shapediver, an online editor specifically designed to show files generated in Grasshopper. It was enough for users to drag some sliders in order to edit colours and geometry of the model, without needing any kind of skill in 3D modeling.

In order to give a physical feedback to users, the mostly often chosen geometries were 3D printed live during the workshop. This way, the experience had an analogic development, parallel to the digital one: due to the availability of a high number of 3D printed parts, it has been possible for users to understand the physical results of their choices.

5. Results and findings

In this section we will thoroughly discuss the analysis of our data sample; as mentioned before, we collected 71 different models and surveys.

Our population sample is quite peculiar, due to the specificity of the Faire in which our activity was held. Two thirds of the participants are male, and almost half of them are very young, between 5 and 12 years old. Only 30% of the participants hold a university degree of some kind, most of them in the area of design and engineering.

The companion robot was the most selected scenario, by 45% of the population; the caregiver robot was selected by another 30%, and the remaining 25% designed the evil robot.
We will now analyze every scenario.

5.1 SCENARIO #1 - Design a robot to give to your son as a present for Christmas

Figure 2. The chart shows the sample distribution of users in the first scenario grouped by age.

A first insight that we can highlight is that most of the users who chose this scenario were very young. We can argue that kids are fascinated by the idea to play and interact with a humanoid robot and are not influenced by adults' suspicions and distrusts towards artificial beings.

Regarding the face, 41% of the participants chose big rounded eyes for their project; they clearly aimed to paint a friendly and kind expression on Poppy's screen.

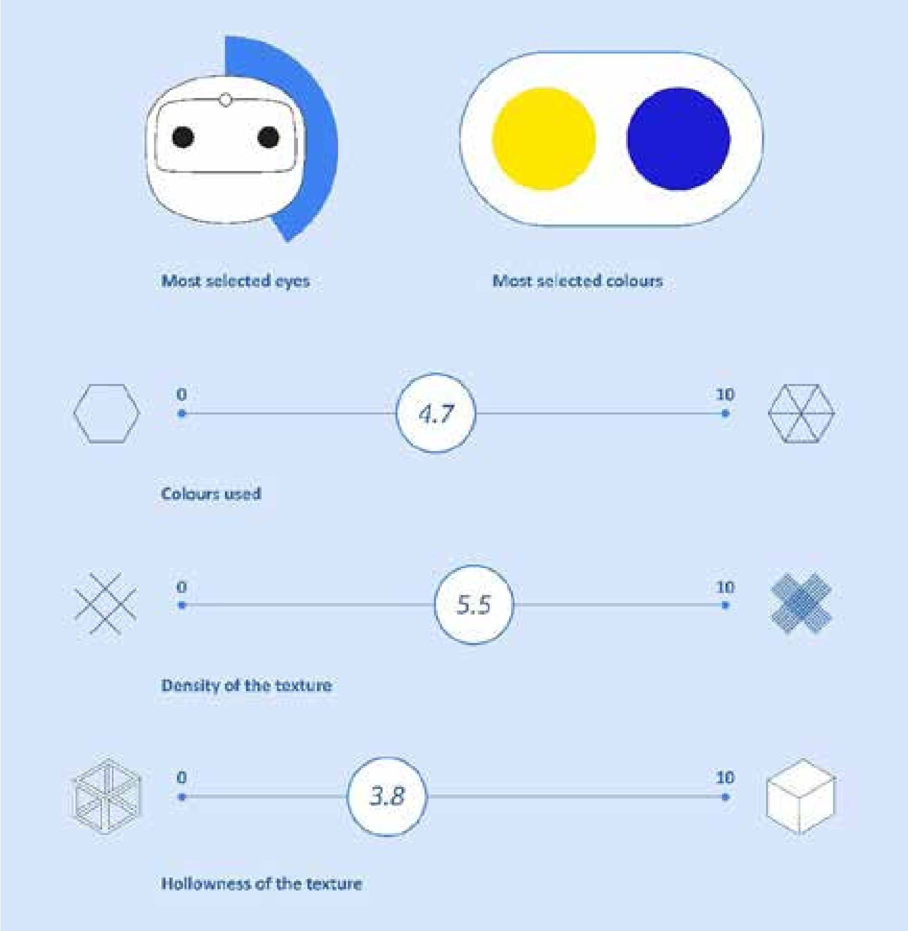

Figure 3. The visualization shows the users choices regarding the design of the robot for the first scenario.

An interesting reflection can be made on colour choice: kids have a tendency to use all the colours at their disposal, and this appears to be evident in our analysis. Even though there is a prominence of yellow and blue, our toy robots present an average of 4.7 colours used in the same model.

We also noticed a tendency that could be expected: girls make a higher use of pink in their design.

Figure 4. The picture presents the archetype of robot designed by users for the first scenario.

Young users were playing a lot with colours and shape of the texture but kept the density of it at an average level.

The chosen textures were mainly quite hollow, generating robots that appear to be lightweight but also sturdy and strong.

5.2 SCENARIO #2 - Design the robot that will take care of you when you will be old

Figure 5. The chart shows the sample distribution of users in the second scenario grouped by age.

This scenario shows a pike of appreciation by 36+ years old users. This may indicate an interest in the market of companion and caregiving robots by a population of adults that will in the future need assistance in their homes.

However, we also recall an interesting trend of kids wanting to design robots for their grandparents, which again shows that youngsters are not intimidated at all by artificial beings that may live with them.

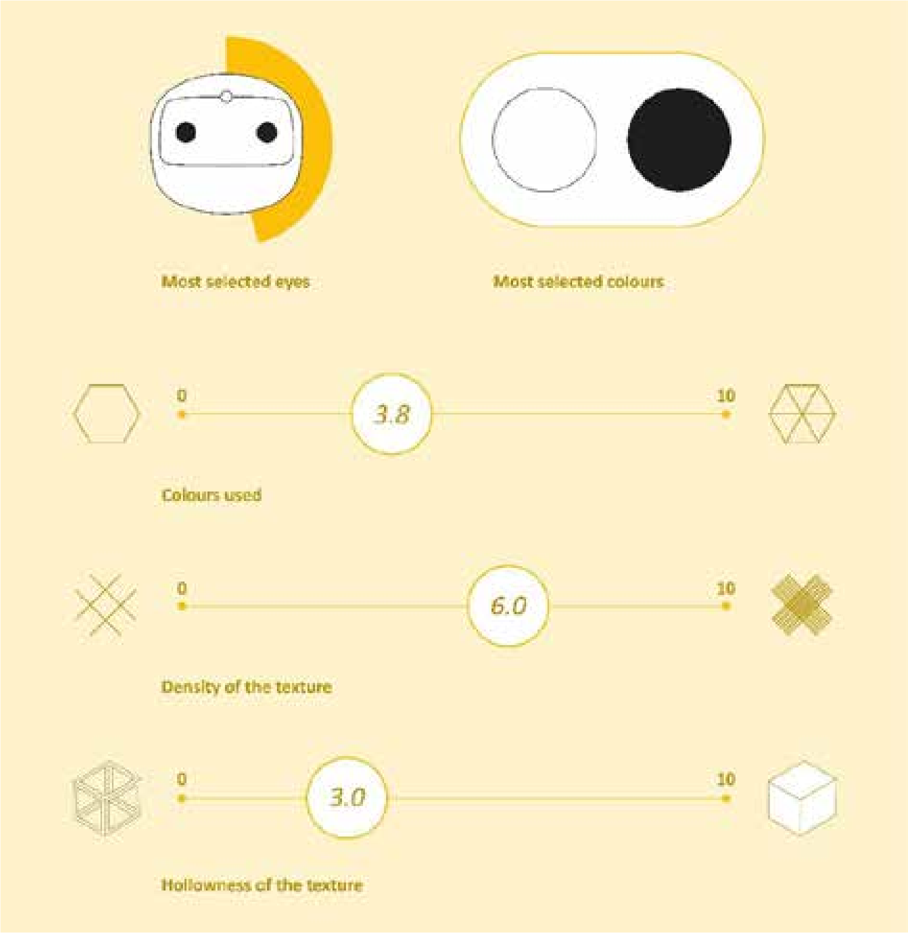

Figure 6. The visualization shows the users choices regarding the design of the robot for the second scenario.

The most selected eyes were again big and rounded, but there is a very different trend in colour choice. In fact, main selected colours in this case are white and black, with an average of less than 4 colours used in a design. This trend is in line with products on the market. Other colours often selected as accent for the design were mainly blue and yellow.

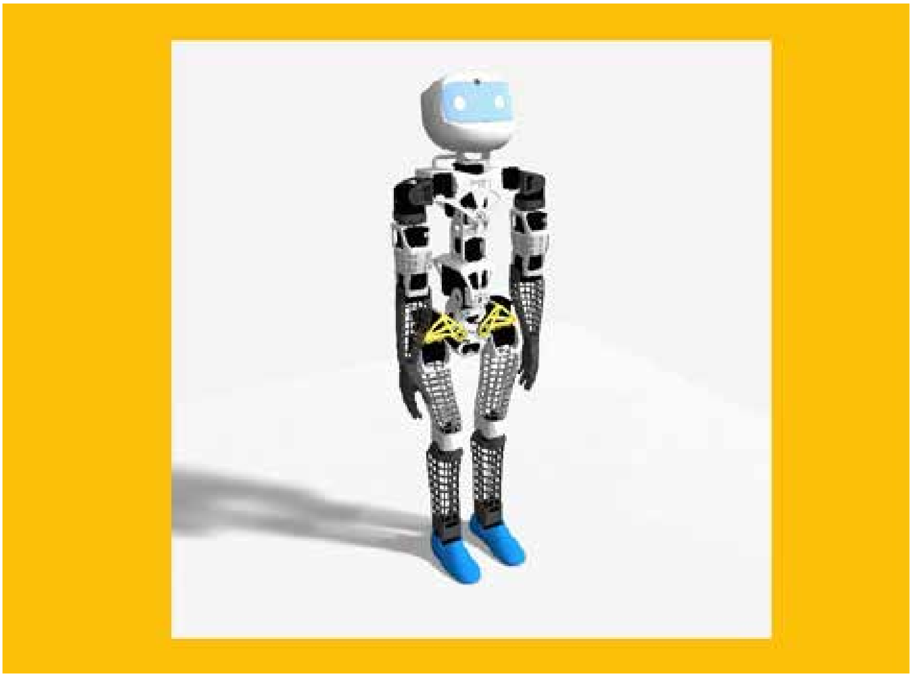

Figure 7. The picture presents the archetype of robot designed by users for the second scenario.

In this scenario we saw a slightly higher degree of density and complexity in the chosen textures, but the most interesting trend regards the hollowness of it: this is the scenario in which Poppy's limbs are lighter. This may indicate that users perceive caregiving robots as life companions who don't need to have a big and intimidating body, but rather a light and tiny structure, easily adaptable to confined environments such as private houses and hospitals.

5.3 SCENARIO #3 - Design the evil robot that is able to submit humanity

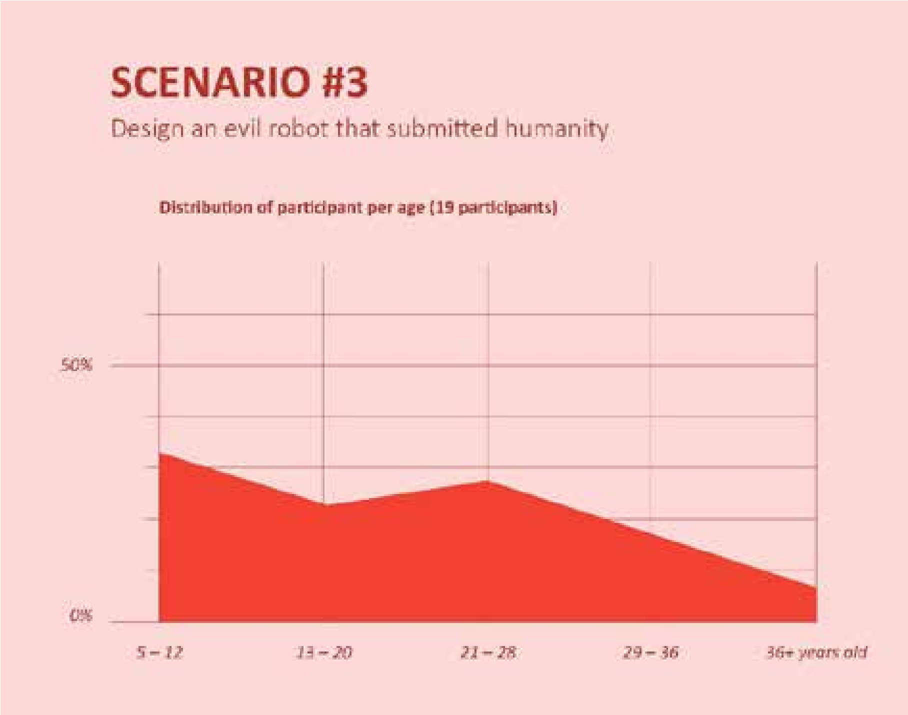

Figure 8. The chart shows the sample distribution of users in the third scenario grouped by age.

This scenario was the least selected; most of the participants that chose it were teenagers enjoying the idea of designing an evil character. Almost 60% of the designs present a stripe in substitution of the eyes; we believe that our users were recalling a recurrent iconographic choice made in movies.

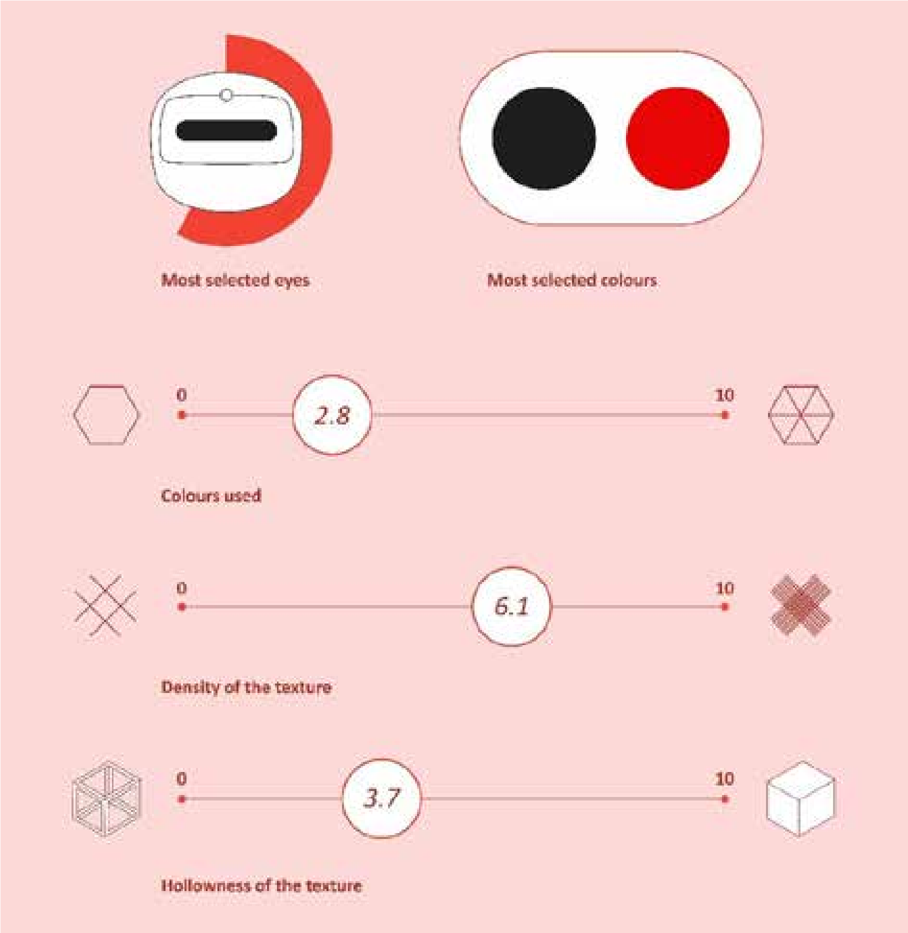

Figure 9. The visualization shows the users choices regarding the design of the robot for the third scenario.

Regarding colour choice, this is the scenario where the average of used colours in a design is smaller: only 2.8%. The most selected colours are black and red.

Figure 10. The picture presents the archetype of robot designed by users for the third scenario.

For what concerns the structure of the limbs, this scenario presents quite complex and dense textures, with a slight preference for the studded texture. Plus, this is the scenario with the less hollow structure.

In general, the evil robot appears to have a clear and well-defined iconography in the imagination of our participants, who surely recall movie and videogame characters when making design choices. Compared to the other scenarios, this is the one that mostly gave us results that we could easily expect to receive.

6. Conclusions

During the period of the faire, visitors have shown interest and involvement in our proposal; direct feedback confirmed that the public is fascinated and curious about the field of humanoid robotics and some of the people we talked to also declared that the possibility of having a companion personalized on their specific needs and tastes was very compelling to them.

We believe that the positive feedback also lies in the innovative method of data gathering and co-design that we experimented. The use of a simple digital platform to edit the project was supported by physical models of the robot and by functioning 3D printers. The participants thus had complete control and understanding of the design process, a situation that is not to be taken for granted in many participatory design experiences. Further developments of the project will hopefully take into account the possibility to program the robot to perform simple tasks, in order to give a complete formative experience to the users, especially the youngest.

In general, we have been able to confirm our hypothesis on people's perception of humanoid robots. In particular, we found that colours hold great importance in the perception of the goodness or evilness of a robot; most of the design choices were made, as expected, based on memories of popular archetypes seen in movies and videogames, especially with regard to facial expression and colour; lightness and small size seem to be important features for companion and caregiving robots, while sturdiness obviously make the user feel intimidated and inferior.

The data sample that we were able to collect has proven to be very useful for our analysis of Human - Robot Interaction patterns. Future experiences will be based on similar approaches, with the goal to find a faster way to collect information, in order not to lose data of participants that had few time at their disposal.

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