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DESIGN CULTURE(S) | CUMULUS ROMA 2021
JUNE 08.09.10.11, SAPIENZA UNIVERSITY OF ROME

Designers' Skills for Social Robotics

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Abstract | The discussion about Social Robotics reflects the way we perceive our present and how we envision the future. Social Robots differ in form and function from their factory cousins based on the context they operate in. Social Robots today tackle loneliness among the elderly, aid patients with developmental and degenerative diseases, help perform household tasks and more. The common denominator among all these roles is intensive contact with humans. This contact draws Robotics out of its technical foundations to seek inputs from other disciplines like Social Sciences, Psychology and Design. The potential of the Social Robotics market leads us to investigate the role Industrial Design could play in it, the skills designers will need to cultivate to participate and the strategies for Industrial Design education to ensure the preparedness of new designers for the field of Social Robotics.

KEYWORDS | SOCIAL ROBOTICS, INDUSTRIAL DESIGN, EDUCATION, HUMAN-ROBOT INTERACTION

1. Introduction

The Neglect of Industrial Design (Ughanwa, 1991) champions the irreplaceability of industrial designers in product creation. Ughanwa argues that for products to gain a competitive edge in the international market, the design of products cannot be left to the Engineers. Ughanwa's industrial designer is not a specialist, but someone who can unify a technological capability with the fulfilment of a desire or need of the user.

In the next decade, Borja de Mozota (2002) reports on Design Management in Europe's top Small and Medium Enterprises (SMEs). The study finds Management employs Design primarily for product differentiation through aesthetic and ergonomic interventions. While the role of Industrial Design begins to be perceived as a major contributor to a market advantage (Drew & West, 2002; Raulik et al., 2008; Europe Economics for DG Internal Market & Services, 2016), the profession is still not considered crucial. In many cases, Design is seen as a sub-field of either Marketing or Engineering. Design is not perceived as a mover in improving product quality or production and most product innovation is driven by marketing, leaving R&D or Design-driven product innovation at a lower priority. The study also analyses what skills managers look for in Design candidates. Imagination and the ability to synthesise and visualize ideas rank much higher than the ability to understand user needs or think laterally. This reflects some of the stereotyping of the designer as more of an aestheticist.

With the advent of Design Thinking around the 2010s, Design as a discipline matured enough to begin influencing other disciplines such as management (Kolko, 2015). Recognising the role of Industrial Design, companies began building in-house multidisciplinary design teams that collaborate with the different departments to create more advanced products (Burton, 2019). Corporations like Apple and Philips that have well-established design teams, helped start the trend of acquiring Design capabilities. Tech players like Facebook, Google and IBM are joined by consulting companies like Accenture, PwC, Mckinsey and Deloitte in acquiring design firms (Maeda, 2016). With the rise of digital products, the focus shifted from products to experiences (Design Council, 2018; Burton, 2019). Consequently, industrial designers now find themselves filling jobs in Design management and User Experience Design (UX) and the profession is adapting to meet the needs of the future.

In the new decade, the growth of Industry 4.0 and the Domestic Appliances market create new opportunities for industrial designers in the technological sector. One of these growing markets is Robotics. While industrial robots used in automated production lines have a well-established foothold in the market, Social and Assistive Robots occupy a considerably small market share. Complex human-robot interactions with these robots demand more thought into their application and usability. As a result, roboticists will need the aid of professionals trained to understand and address user needs- Industrial Designers.

2. Service and Social Robotics

The earliest mentions of Social Robots, in the present context, occur in the 1970s by when the idea of the robot had already been popularised considerably through science fiction literature and film. In a 1978 Interface Age edition dedicated to the theme of robots, F.W Chesson discusses the evolution of robots and lays out the physical and technical requirements for a possible Social Robot tasked with supervision. The article discusses the use of sensors, Artificial Intelligence, and features such as obstacle avoidance that are still relevant to robotics. In the forty years since robots have overcome numerous technological hurdles to make their presence in human lives not just possible but essential.

Broadly, a robot is a programmed physical entity that perceives and acts autonomously within a physical environment which has an influence on its behaviour meaning it manipulates not only information but also physical things (Kaplan, 2005). The International Federation of Robotics (IFR) defines two main services offered by robots: (a) servicing humans (personal safeguarding, entertainment etc.) and (b) task performance and equipment servicing. A Service Robot is thus “A robot which operates semi or fully autonomously to perform services useful to the wellbeing of humans and equipment, excluding manufacturing operations.” (Hegel, 2009). Similarly, the International Standards Organisation (ISO) defines “Service Robots” as robots that “perform useful tasks for humans, which aid in physical tasks such as helping people move around”.

Professional, personal, and domestic Service Robots in 2019 had a combined market share of 17.2 billion USD with logistics and floor cleaning robots making big gains (International Federation of Robotics, 2019). The overall demand for Service Robots is boosted by socio-economic changes (medical, cleaning, entertainment robots) and industry strategies (collaborative, logistics, maintenance robots). As Service Robots grow more ubiquitous, they will have to evolve to adapt and interact more holistically with humans.

In contrast to Service Robots, Social Robots are designed to communicate with people. Chatbots are also designed for that purpose, but a social robot is physically embodied (Korn et al. 2018). Social Robots are explicitly developed for the interaction of humans and robots to support a human-like interaction (Hegel 2009). Bartneck and Forlizzi (2004) define a Social Robot as an autonomous or semi-autonomous robot that interacts with humans by following the behavioural norms expected by the people with whom the robot is intended to interact. If robots are to make this leap, Robotics must grow out of its technological roots.

3. Social Robotics as a Multidisciplinary Field

Roboticists are conventionally engineers with competencies in Electronics, Mechanical or Computer Engineering. These roboticists may also specialize in fields such as Artificial Intelligence, Machine Learning or Computer Vision which significantly augment robot capabilities. Complementing these individuals are, often, professionals from the fields of Psychology and Sociology, called on to help create the “Human” element of the robot.

Multidisciplinary cooperation in robotics began to gain importance in the mid-90s and early 2000s when events and conferences brought different interest areas, in the field of robotics, together. “The IEEE International Conference on Robot and Human Interactive Communication (RoMan)” that started in 1992 and conducted annually to this day was one of the first such events. Initially, this conference was mainly attended by experts in robotics from technical fields but in recent years the conference has attracted more multidisciplinary researchers. In 2000, the IEEE / Robotics Society of Japan created an international conference on humanoid robots that put the spotlight on robot behaviour and anthropomorphic robots and in 2001 the United States National Science Foundation and the Defence Advanced Research Projects Agency (DARPA) sponsored the first seminar on Human-Robot Interaction (HRI) (Burke et al., 2004).

Such events brought together a highly specialized and multidisciplinary group of researchers who worked in fields associated with HRI and allowed roboticists to interact with experts from various sectors like Psychology, Sociology, Cognitive Sciences, Communication Sciences and Human-Computer Interaction. We can, hence, consider these events pivotal in the establishment of Social Robotics.

Social Robotics has also been advanced by robotics competitions. Two early competitions in the field were the “Association for the Advancement of Artificial Intelligence (AAAI) Competition and Exhibition” and the “Robocup Search and Rescue” (Kitano et al., 1999). The challenges involved the development of robots capable of rapidly analysing their surroundings under extreme conditions and completing their search and rescue task. The rich Human-Robot interactions in these challenges led participants to focus on resolving HRI problems.

In recent years, these competitions have expanded on the original scope resulting in the birth of events dedicated to Assistive Robots. The HRI challenges in this domain include physically supporting the user safely and designing effective social interactions through cognitive and emotional approaches, often through natural interactions like gestures and speech.

These conferences, seminars and competitions highlighted the need to establish inclusive interdisciplinary interactions, to create a common working vocabulary for this field, diversify the areas of application based on the interests of each discipline and organise fieldwork for HRI experts to validate and test concepts. These events also created great opportunities for technology transfer between disciplines and helped identify new opportunities for such technology in society.

The development of robotic assistants in the socio-cultural context poses many challenges. Besides technological limitations (sensor accuracy, actuator response speed, processing capabilities etc.), participation and synergy between the technical and non-technical teams involved in the project are also issues since the success of the robot is not only determined by technical efficiency but also by its effectiveness (Šabanović et al., 2009). Depending on the context of the application, it is also possible to involve other professionals, for instance, doctors, patients, and caregivers in the case of assistive robots or teachers, students, and parents for educational robots. The design of socially interactive robots can thus be seen as a catalyst of knowledge that can lead to the creation of a “Hybrid Science” (Caporael 2000).

The research covered in this paper is aimed at understanding the present and future roles of Designers in this multidisciplinary field of Social Robotics.

4. Statistical study of Robotics teams today

The first part of the research consisted of the statistical analysis of the role of designers in current Social Robotics companies. It was carried out by web scouting using keywords associated with the design and production of robots. Web scouting resulted in an initial list of 42 companies. This initial list was reduced, excluding industrial robot companies, maintaining companies working on Social Robots. A second reduction resulted from inadequate data found on company websites or insufficient data on the role of team members, their education backgrounds, or their professional profiles. Some of this data was drawn from the interviews we conducted and some from cross-checking team listings with profiles on professional social networks. Another point to be noted is our inclusion of profiles requested for job openings in addition to the composition of existing teams.

Our final sample comprised of 22 representative companies in the field of Social Robotics. They consisted of 1 large, 6 medium, 9 small and 6 micro enterprises. A considerable number of them were spinoffs from research institutes and universities. We analysed employee roles associated with robot development avoiding administrative and marketing roles. We also analysed the educational background of the employees.

Professional roles were classified into 11 categories:

- 3D: 3D Modelling, Animation, Character Design
- AI: Artificial Intelligence, Motion Analysis, Computer Vision, Speech Technology, Sensing
- BM: Biomedical, Human Behaviour, Assistive Technologies
- EL: Electrical and Electronics Engineering
- GR: 2D Graphics, Communication, Web Design
- ME: Mechanical Engineering
- RO: Robotics, Materials, Mechatronics, Energy/Autonomy management
- SW: System Software, IT architecture, Firmware Development
- TA: Assembly, Testing, Maintenance
- UI: UI/UX Design, Interaction Design, Web Interface, Games
- OT: Other roles

The different educational backgrounds were classified into 9 categories:

- BM: Biomedical Engineering, Physical Therapy
- CS: Computer Science, Software Development, Software Engineering
- DE: Graphic or Industrial Design
- EL: Electronics or Electrical Engineering
- JT: Junior Technician, Trainee
- MA: Mathematics, Statistics
- ME: Mechanical engineering
- RO: Robotics or Mechatronics Engineering
- ND: Undefined

From the analysis of data of the selected companies, we obtained 138 professional profiles for comparison. From these, we were able to identify 31 different combinations between job roles and educational background (see Figure 1).

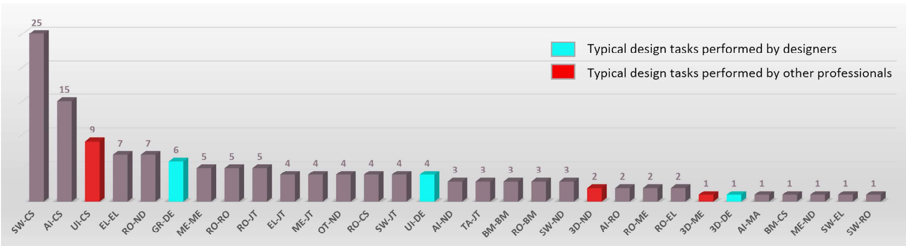

Figure 1. Comparison of job profiles and educational backgrounds in professionals engaged in the Social Robotics industry

From the graphical analysis, it is evident, at 29% of the total dataset, that software developers with the relevant educational background comprise a significant part of robotics teams. In total, if we consider all software development, including Artificial Intelligence (AI) and other machine intelligence specializations, software developers/engineers occupy around 40% of the total dataset. In the classification we distinguish between the two groups, to highlight the demand for specialists in machine intelligence in addition to developers needed to program functional aspects of robots.

The second most significant participation is from professionals that characterize the sector- Roboticists. Under this banner, we include profiles such as 'Robotic Engineer' and 'Robotic Technician', professionals who specialise in mechatronics. This role occupies 20% of the dataset and professionals in these roles come from many different educational backgrounds.

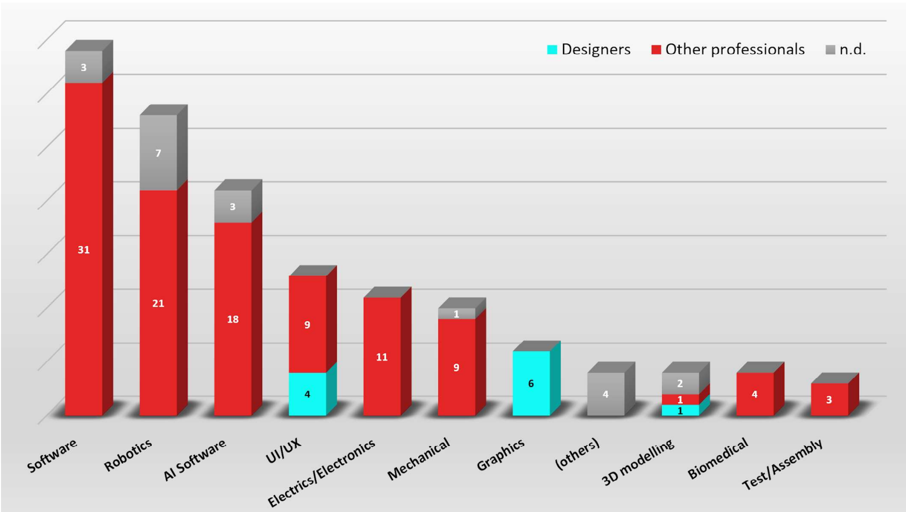

Figure 2. The proportion of Designers engaged in different profiles in the Social Robotics Industry

The next most significant role is that of User Interface/ User Experience designers (UI/UX), a design specific role. They comprise of around 7% of the team but what is noteworthy is that a greater proportion of these specialize in, or come from an educational background in, software development rather than Design. Only 36% of UI/UX roles in our dataset are occupied by designers.

Altogether, considering the most typical design roles (2D/3D design and UI/UX), which comprise 17% of the total, we note that of these roles 52% of the positions are occupied by non-designers, generally software developers. The only sector where designers are exclusively employed is in 2D graphics, web, and communication design.

The overall picture, though not exhaustive, seems to confirm the fact that, even considering only social robotics companies, which by definition must pay particular attention to the relationship between people and machines, the designer is still mostly required to perform graphic and communication tasks. In the sample, of 8 companies with UI/UX positions only 2 employed designers while the others employed computer scientists. One possible reason for the lack of designers in the industry could be that many small robotics companies are spin-offs from technical institutions and are more focused on functional performance.

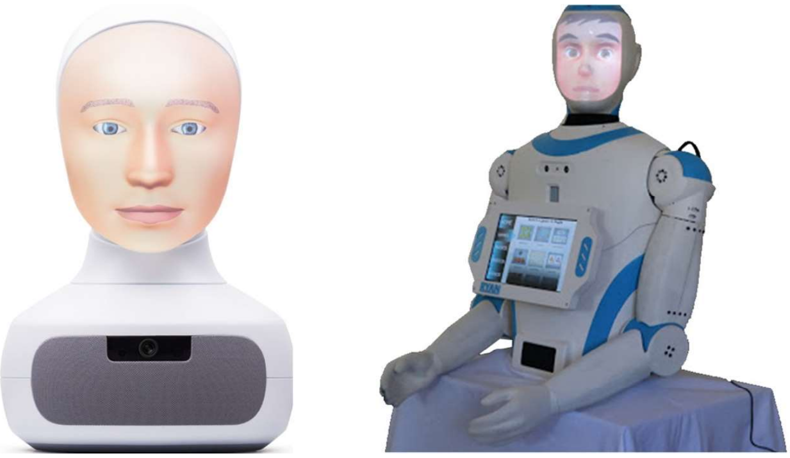

Figure 3. Furhat Robotics (Sweden), a small enterprise that produced Furhat (left), involves designers in UI/UX while DreamFace Technologies (USA), a micro-enterprise that developed Ryan (right), has engineers managing UI/UX (Image sources: Furhat Robotics, DreamFace Technologies)

These findings seem to demonstrate that the participation of designers in the Social Robotics industry is not high. To investigate the reasons for this we conducted interviews with professionals in the sector.

5. Expert Interviews

This section of the research was aimed at gathering information from the industry experts on the present situation of design in Social Robotics to synthesize strategies for Design Education in the future. Five interviews of individuals from robotics companies and research institutes, primarily those that deal with Social or Assistive Robotics were conducted: Dr Maria Rosanna Fossati (Researcher, IIT Genova), Mauro Puttolu (Sales Manager, Jampaa), Will Jackson (Director, Engineered Arts), Dr Manuele Bonaccorsi (CEO, Co-Robotics) and Alexandre Colle (PhD candidate, Edinburgh Centre of Robotics and Co-founder of Konpanion). Of the organisations of our interviewees, 2 had in house designers and the other 3 either collaborated with designers on projects or outsourced design tasks. The organizations are based in Italy and the UK.

5.1 What can designers do?

According to Fossati, a designer can play several roles in the Robotics industry. The most common role is that of an aestheticist who intervenes, often in the final phases of the project, to work on the embodiment of the robot. This and the role of the graphic designer help give the robot a competitive edge in the market. However, this shouldn't be the primary role of a designer who can also participate as a facilitator between the product development team and end-users to better understand the needs that must be addressed by the product and the end-users' comfort with the final product beyond functionality. Designers can contribute to robotics through research as well. In literature, Valoten (2005) explains of the existence of these roles based on the evolution of Finnish Industrial Design. The role of the designer as an aestheticist comes from the early days of Design where artists were brought in to create new forms for products. Design Research came with the advent of ergonomics when aspects of the design process were being codified as a scientific methodology and not merely an artistic expression. Designers as facilitators arose in the 1980s with the rise of Design Management and with the rise of the branding era in conjunction with the technological boom, industrial designers became involved in providing User Experiences. Another interviewee Mauro Puttolu feels that this task of improving the User Experience along with Problem Setting are the most important roles designers can play in Robotics. However, his company has seldom worked with industrial designers. It is not uncommon for companies to outsource their design tasks. Hiring a design agency can bring in fresh perspectives, but often, this approach looks at design as value addition and not as an integral part of product development. Instead, in-house design teams require less time to familiarise themselves with the company's needs as they have a more intimate knowledge of the company's project, resources, capabilities and market objectives. Will Jackson's Engineered Arts is one such company and as one of the in-house designers he says, "Robotics is an integration challenge - the mechanical parts must fit with the external appearance and the software interface must be easy and accessible to use".

5.2 Design in a multidisciplinary approach to Robotics

The collaboration between different fields such as engineering, informatics, natural sciences, cognitive sciences, design, arts, medicine, and education shows how different research methods and work practices are as necessary as they are problematic. Work involving different backgrounds and approaches can often lead to misunderstandings. Confusion over terminology is probably the most common cause for confusion. The meaning of a term may vary depending on the discipline (Šabanović et al., 2007). Fossati notes how the disciplines each have their own language, vocabulary, work practices and toolbox. This makes it hard for the different fields to dialogue, let alone collaborate operationally.

Despite this observation, most of our interviewees agree that the solution to resolve such differences is multidisciplinary collaboration. Jackson identifies the conflict between a designer's idea and engineered reality as the result of hiring designers with no practical experience and urges designers to experiment and understand feasible production methods and material properties. Manuele Bonaccorsi offers a different perspective saying it is important for engineers to work with other disciplines. He makes a case for interdisciplinary courses at universities where designers come in contact with technology and engineers get to collaborate with designers to broaden their understanding of the application of technology. This approach will better equip students from both disciplines for professional projects, which are increasingly multidisciplinary. Alexandre Colle, concurs, saying designers and engineers cannot work without each other while developing products. Design, according to Colle, is a holistic discipline where you must consider the needs of users, the environment and the market. Colle stresses that designers must engage more with engineers and advocate the potential of design thinking in robotics. For Colle, multidisciplinary education brings together not only Design and Engineering but also Psychology, Business and other fields that create new opportunities for meaningful outcomes where technology is not an end but a means.

6. Conclusions

Our conclusions on the skills an Industrial Designer should possess to integrate into a Social Robotics development team are based on desktop research on the development of social robotics, studying market forecasts in this sector, analysing robotics team compositions and the educational backgrounds of team members. In addition, expert opinions were sought through interviews. Our conclusions also include our experiences developing Social Robots in multidisciplinary teams (Bonarini et al., 2016) and the courses we teach in this field (Bonarini & Romero, 2013).

6.1 General Skills

Industrial designers' core skills, as developed in professional courses, will continue to be indispensable in Robotics and designers must be highly competent in using these skills. Industrial designers will have to bank on their ability to identify problems from comprehensive assessments of user-needs conducted through interviews and research. Designers will always be relied on to be creative and solve problems radically. This said industrial designers must be extremely capable at representing ideas through 2D sketches as well as 3D models both physical and digital. Models must not only convey the aesthetic appearance of products but must take due consideration of the production processes involved. To this end, industrial designers must be knowledgeable in the existing industrial methods, materials, and their properties. It is highly recommended that during the iterative prototyping process designers experiment with the materials and processes to improve their understanding of the practical feasibility of their ideas.

6.2 Technical Skills

Robotics development and arguably all product design is inherently tied to engineering. Thus, designers must educate themselves in Mechanics, Physics, Computer Science and Electronics to be able to communicate effectively with engineers in the field of robotics. We do not intend for designers to become experts in these fields but to have sufficient working knowledge of the principles and become familiar with the language used by these fields. A multidisciplinary approach to problem-solving requires designers to be prepared to work alongside professionals from other fields. Thus, industrial designers must seek experience on collaborative projects, working with engineers, to better integrate into robot development teams. In robotics, designers must be able to produce functional prototypes to demonstrate interactions and basic functionalities. To achieve this, they must be capable of developing electronic circuits employing sensors and actuators or of programming interactive displays. This requires them to extend their knowledge of prototyping to include electronics and informatics. Fortunately, development platforms for electronics firmware and software tools to develop web services and mobile applications, have made this easier today by abstracting many of the complexities. Nevertheless, Designers must be prepared to learn to use new software and we strongly advise gaining some proficiency in computer programming since coding is now an integral part of a broad spectrum of software tools. The rising demand for UI/UX design makes these skills an indispensable part of an Industrial Designer's toolkit.

6.3 Social Science Skills

Improving User Experiences is heavily influenced by the understanding of human factors. These are studied in detail in psychology, sociology, medicine and design. Referring to research and consulting experts in these areas must be part of the methodology used by industrial designers to create better Human-Robot Interaction. From the perspective of product design, it is evident that the experience of using an object is multisensorial. In robotics, this is even more important considering there are not only affordances from the embodiment to consider but also responses and feedback that must be designed as part of the robots' behaviour.

There is a great role of context and culture to the success of a project and designers must always be perceptive of the user's expectations and concerns. This calls on designers to contribute as researchers by staying informed of current trends, market opportunities, technological advancements and scientific breakthroughs in different fields that can lead to new innovations.

6.4 Soft Skills

The multidisciplinary nature of Design positions industrial designers as mediators in the workplace. Visual representation skills that are part of a designer's foundation has great potential to be utilised to communicate information more effectively between disciplines and departments. Industrial designers must improve their communication skills to dialogue with professionals from different backgrounds as well as to advocate for the integration of design in the development process. For human resources, this ability of designers to collaborate and cross-pollinate across disciplines would be invaluable. Part of the communication skills required is the ability to listen and discuss. Designers must then be able to extrapolate and synthesise the gathered information into new ideas. Lateral thinking is essential for Industrial Designers to aid in solving technological problems with creative ideas.

Thus, we posit, for Social Robotics still in its nascent stages of market maturity, there is much an Industrial Designer can contribute towards creating new paradigms in robotics and providing inputs that could give Robotics companies a market advantage.

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