ARCTURUS: Architecture for Sustainable Industry 4.0

Sonia Yousaf [1]

[1] *University of Huddersfield, Queensgate, Huddersfield, United Kingdom*

Abstract

Throughout time, there have been many industrial revolutions, and we are in the midst of the fourth; witnessing the increased use of cyber-physical systems, artificial intelligence, the Internet of Things (to name a few) in industry settings. Despite Industry 4.0(I4.0) technologies being primarily factory based, their applications have trickled into other sectors, including health.

Health 4.0(H4.0) makes use of the technologies in I4.0, and applies them to settings such as surgery, disease detection, and personalised healthcare with robotics. As with all technology, there is a need to consider making these developments sustainable. Very little has been done to apply sustainable development frameworks and techniques that cover sustainability dimensions into the design of H4.0 technology and its deployment.

The key area of focus for my PhD is sustainable development in social robots within an assisted living setting for elderly people- involving an exploration with a robotics company as a case study.

Keywords

Industry 4.0, Health 4.0, Sustainability, Robotics, Assisted living, Elderly care.

1. Introduction

The motivation behind this research stems from an undergraduate dissertation completed in 2022 at the University of Huddersfield. This project was titled "Incorporating sustainability into the Agile software development method", and involved a company case study that will again be applied to the current research. This work was important as it highlighted the lack of work done into "how" the dimensions of sustainability are being addressed, specifically within technology corporations. This is a reflection of a wider issue globally. As members of the rapidly advancing field of technology, those studying computing have a responsibility to raise awareness on the consideration of sustainability impacts that designs will have both temporarily and long-term on the planet, society, and businesses. This work could serve as a reference point and tool when pursuing sustainable design for those within the social robotics field. This research is conducted under the supervision of Dr Colin C. Venters (UOH), Dr Leticia Duboc (La Salle BCN), and Dr Raquel Ros (La Salle BCN).

2. Background

In order to aid and partake in the United Nations (UN) call to action in achieving as many of the 30 Sustainable development Goals (SDG's) set to be accomplished for the year 2030, businesses must place a focus on their contributions to sustainability. Over the decades, there has been an increase in interest on "topics related to sustainability". The main dimensions are "environmental, social, and economic", with environmental being the one that most companies across the years have placed importance on [1]. There are additional dimensions less considered, but of importance, such as "individual" and "technological", with authors also suggesting others. The impact of developments on the dimensions of sustainability must be considered within the design process as issues such as

pollution, climate change, the extinction of species, and water scarcity are of concern. Until recent years, businesses have treated sustainability as an optional function, but with legislation increasing the responsibility of firms to fulfil sustainability duties, managers must look to more "sustainable managerial decision making" [2]. This involves greater action to tackle a firm's efforts, as well as minimising impacts that are detrimental to sustainability issues.

The area of interest for this work is within social robots, a market that reached $3.4 billion in 2022 [3] and continues to grow as uses widen and expand from commercial to personal. The development of such products is extensive and involves intricate hardware, complex software and the study of human-robot interaction (HRI) - each of which should consider sustainability dimensions, as they have great impacts.

3. Research Questions

The ultimate goal of this research is to incorporate a framework/solution for considering sustainability into the development of social robots, distinctively assisted living robots. This framework will work within the company case study and should be transferable across other organisations.

At present, the research questions are:
1. What is being done to address sustainability within the development of assisted living social robots?
2. What are the frameworks deployed within the design process of robotics that addresses sustainability?
3. Where in the development process could a sustainability framework or tool be applied?
4. What are the benefits and challenges of applying a sustainability framework/tool within the development of social robots?
a. What are the short-term effects of such action - on the company and externally?
b. What are the long-term effects of such action - on the company and externally?

4. Research method

The proposed method will involve a mapping study and a systematic literature review to gain further detail on what is being done within the field of research. These should present any frameworks that are currently being applied or could be used within the field of robotics. Following on from this, the frameworks/tools will be compared in order to detect those that serve as prospective solutions. These frameworks can then be revised and improved.

In addition to this, an exploration of a robotics company will be completed in order to analyse the areas in which an intervention can be applied. The primary data that will be collected will be qualitative, consisting of descriptions and accounts of processes and development timelines. In addition to this, the thoughts of the employees must also be considered. This will involve the reiteration of data collection in order to gain better understanding, leading to an analysis that is significant, important, and displays actions to carry out based on what has been seen, answered and done [4]. The application of the framework would be measured to examine both the short and long-term effects and the success of application.

5. Results to Date

At present, a mapping study is underway which involves search terms revolving around sustainability within: "Health 4.0", "Social Robots", and "Assisted Living". The searches are further expanded to include other terms used for assisted living and social robots, to ensure the scope is extensive and covers relevant areas, as well as alternatives to the word sustainability.

From the initial 3 searches there were 99 publications, and upon applying the exclusion and inclusion criteria, this number revealed 20 publications. The data extraction confirms that there are a small quantity of publications that address sustainability, with even fewer addressing multiple dimensions of

sustainability at one time. The searches were expanded to include 2 more search strings, bringing the total number of results to 393 before inclusion/exclusion criteria.

The lack of action taken to tackle sustainability concerns at the development stage ratifies there is a gap in literature. It is worth noting that most publications are of recent years, showing an increase in relevance. The next step will be a scientific literature review (SLR) to delve further into the exact details of frameworks/solutions that are being applied within the areas.

6. Next Steps

As the project is at its early stages (6 months), the focus at the moment lies with establishing evidence supporting the gap in research and the need for action required to address sustainability in the context of social robots. Once the mapping study and SLR are completed to a high quality, frameworks, and their relevance in the setting of robotics development will be looked into and compared. This could involve speaking to professionals within the robotics industry, as well as within academia in order to obtain their views and recommendations of tools that could potentially be applied.

7. Acknowledgements

8. References

[1] Fischer, D., Brettel, M., & Mauer, R. (2020). The three dimensions of sustainability: A delicate balancing act for entrepreneurs made more complex by stakeholder expectations. Journal of Business Ethics, 163(1), 87-106. doi:https://doi.org/10.1007/s10551-018-4012-1

[2] Dao, V., Langella, I., & Carbo, J. (2011). From green to sustainability: Information technology and an integrated sustainability framework. The Journal of Strategic Information Systems, 20(1), 63-79. https://doi.org/10.1016/j.jsis.2011.01.002

[3] iMarc. (2023). Social Robots Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2023-2028. iMarcgroup. URL: https://www.imarcgroup.com/social-robots-market.

[4] Walliman, Nicholas. Research Methods : The Basics, Taylor & Francis Group, 2021. ProQuest Ebook Central. doi: http://ebookcentral.proquest.com/lib/hud/detail.action?docID=6809774.