



Intelligent clothing for the ageing body. The pursuit of a design method

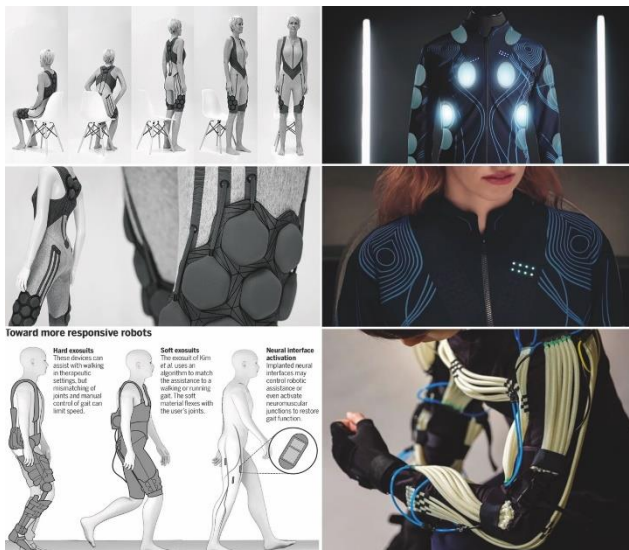
Impact Case Study

Alessia BUFFAGNI
Università IUAV di Venezia
School of Doctorate studies

Year of completion:	2021
Discipline/field:	Design Science
Type of Doctorate (e.g. PhD, DDes, ArtD)	PhD
Supervisor(s)	Medardo Chiapponi


Abstract

The extension of life that medical science and technology have assured mankind in the last century is an unprecedented achievement, a success of delicate administration for social policies worldwide. Life expectancy is increasing, and so is the demand for long-term health care. Starting from the original principle of bio-extension (temporal, anatomical, qualitative), the research introduces in its first part (also through field observation) an overview of the natural and pathological disorders of



ageing and the social strategies to cope with them. Thus, it proceeds to examine the technological innovations (prosthetic, handheld, wearable) that in the past and to date have compensated for the human body's capabilities. It compares those in production and under study that keep serving the purpose by adapting to the demographic change, changing themselves, becoming more and more intelligent and more adherent to the no longer young bodies that they are designed to assist.



Period	High and stable capacity	Declining capacity	Significant loss of capacity
Risks and challenges	Risk behaviours, emerging NCDs	Falling mobility, sarcopaenia, frailty, cognitive impairment or dementia, sensory impairments	Difficulty performing basic tasks, pain and suffering caused by advanced chronic conditions
Goals			
Responses	<p>Reduce risk factors and encourage healthy behaviours</p> <p>Early detection and management of chronic diseases</p> <p>Build resilience through capacity-enhancing behaviours, strengthening personal skills and building relationships</p>	<p>Implement multicomponent programmes delivered at primary health-care level</p> <p>Treat the underlining causes of declines in capacity</p> <p>Maintain muscle mass and bone density through exercise and nutrition</p>	<p>Interventions to recover and maintain intrinsic capacity</p> <p>Care and support to compensate for losses in capacity and ensure dignity</p> <p>Rapid access to acute care</p> <p>Palliative and end-of-life care</p>

Once offered a projection of what their evolution would be (already underway, but for the most part still to be accomplished) toward a full-functional symbiosis with the human they dress, the analysis returns to focus on present day and the central consideration of the thesis: what it means—and, mainly, what it implies—to design for, around, on (if not even inside) a body in pain. The research ends with the third section: the drafting of the design guidelines for researchers who want to commit to the same field, and the assembly report of a prototype meant not as a finished industrial product but rather an additional (three-dimensional) platform for future studies. The implementation aims to answer to one of the central research questions (how Design Science, at its state of the art, can be applied to rehabilitative therapies for the elderly at risk) and will finally clarify the contribution that the thesis intends to bring to Design Science and the material culture of the product. And, more specifically, to the field of Gerontechnology.



Summary of impact beyond academia

The research tries to shed light over a path that is almost uncharted: the design of intelligent clothing for the elderly. It aims to outline a reproducible and improvable map that shows, in the practice of design, how present-day technology can adapt to the body of the elderly.

The research contribution is also to show what opportunities soft sensorization offers for geriatric diagnostics and rehabilitation, even more so if 'intelligently' combined with air actuation systems.

Upgrades:

- If research on F-TEGs (flexible thermoelectric generators) progresses as expected, an upgrade to a fully self-powered product will be soon conceivable.

- Research can already develop the thesis study on pneumatic actuation and therapeutic function in an alternative way: the controlled airflow actuation can be extended to new anatomical regions (by continuing to work with physiatrists and therapists, the possibilities for development are many and promising).

- In support of a more extensive actuation, and using more refined MCUs and firmware, even the architecture of the soft sensors can be enhanced: new soft sensors can monitor more body parts and provide a wider picture of the patient's physical state (a patient who could practice remote physiotherapy sessions, alone or under the supervision of a family member).

Underpinning research, context and summary of methodology

The research is divided into three streams of analysis. The first, 'Design Science and Population ageing', focuses on third age disorders (a theoretical examination on primary, pathological, social ageing accompanied by direct field observation) that lead to the definition of the research questions: which technologies can extend, prolong, support the body's functional capabilities?

Which can help to reduce the risk of falling for the elderly?

How can they correct posture and balance without being invasive?

Can they restore confidence in the body and alleviate the post-fall syndrome, therefore contributing to prevention of falls and the 'overall well-being' of the individual?



Or, broadly speaking: In which way, most useful to our time, can we design around the body of the elderly?

The second section 'Wearing technology' explores those technological innovations that have supported and prolonged the abilities of the human body (prosthetic, portable, and wearable), also presenting a first outlook of what their evolution is toward the 'functional symbiosis' with the human body they dress. In the third and final section 'Dressing the third age. The 'smart' project', the two previous analysis come together to arrive at the drafting of the design guidelines and the assembly report of a prototype – the case study that validates the research thesis: how Design science, today can be applied to rehabilitative therapies for the elderly.

Two methodologies have been applied: first, research for design (sections 1 and 2), which is intended as a path of analysis that is functional to the processing of a product (a study activity where design is at the same time the subject of the research and the beneficiary of the knowledge generated by the action of making research); then the second (section 3), research through design, which is aimed at the very 'practice of design' and collecting the notions generated by experimentation. In this very phase, the development technique is that of iterative design: a cyclical process of elaboration, testing, analysis, and revision. Through a sequence of rectified versions (three shape revisions, two of which are radical), the prototype becomes a research tool to gather new data and update and evolve the design, eventually leading to the design of an 'industrial drawing'.

References produced by researcher from/during doctoral research

Buffagni, A. (2023). Designing a Soft-Actuated Smart Garment for Postural Control and Fall Prevention in Elderly Women. In: Spinsante, S., Iadarola, G., Paglialonga, A., Tramarin, F. (eds) IoT Technologies for HealthCare. HealthyIoT 2022. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 456. Springer, Cham. https://doi.org/10.1007/978-3-031-28663-6_10

Buffagni A., Modellare la tecnologia sul corpo che invecchia. La ricerca di un metodo. Milano, Mimesis Edizioni, 2021. ISBN 9788857585529

Indumenti intelligenti per la terza età. La robotica morbida come chiave di cura 3a Notte della Ricerca di Vicenza – Biblioteca Civica Bertoliana <https://www.facebook.com/biblioteca.bertoliana/videos/631286771195399>



Designing smart clothing for fall prevention in older adults. DesignTech 2019 International Conference at Technion, Israel Institute of Technology, Haifa (Israel) 18-19 giugno 2019 <https://www.youtube.com/watch?v=f-44f1TrYQ4>

Buffagni A. (2019) Designing smart clothing for fall prevention in older adults. A brief overview on the current status. Conference Proceedings of DesignTech 2019 International Conference at Technion, Israel Institute of Technology, Haifa (Israel) 18-19 giugno 2019, ISBN: 978-965-572-991-7

Details of impact

Impact during doctoral research:

Field observation from October to December 2018 at:

- Jaba Jefferson Area Board for Aging, Charlottesville, Virginia, USA
- The Colonnades Senior Living Community, Charlottesville, Virginia, USA
- The Kidney Center Clinic, University of Virginia Health System, Charlottesville, VA, USA

Soft actuators prototyping:

- D-Air Lab Dainese (Vicenza - Italy)
- New Punto Plast (Cervarese S. Croce, PD - Italy)

User testing at San Marco Rehabilitation Center of Vicenza, (Vicenza - Italy)

Project review with doctors and specialists:

- Dr. Alessandra Geremia, GP (ULSS 2 Treviso - Italy)
- Dr. Massimiliano Mosca, Geriatrist (ULSS 2 Dolomiti - Italy)
- Dr. Teresita Fabris, Physiatrist (San Marco Rehabilitation Center of Vicenza - Italy)
- Dr. Andrea Beltramin, Physiatrix (ULSS 2 Treviso - Italy)



This Case Study is an outcome of the D.Doc Project, funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

For more information on D.Doc visit <https://d-doc.eu/>