COMPLEX PROJECTS

TWIN ANATOMY
Hospital of a Human Data Twin

Research Plan

Sumeet Joshi

2023-2024

COMPLEX PROJECTS

Berlin studio
Bodies & Building

Studio
AR3CP010
AR4CP010

Student
Joshi Sumeet (5823498)

Chair
Kees Kaan

CP studio coordinator
Hrvoje Smidihen

Main Tutor
Olindo Caso

Building Technology Tutor
Jan van de Voort

Third Tutor
Martin Grech

Research tutor
Georg Vrachliotis

INDEX

INTRODUCTION

01

Thesis topic

Experiences within a city emerge from a dialogue between its inhabitants and the buildings situated in the urban landscape. As daily users, we often navigate through different buildings, each providing space, light, and shelter for specific activities. The design of these buildings is rendered by specific needs of the bodies (users in this case) correlated to movement, measures, safety, and security, thus influencing the overall experiences of the activities. In our current information-centric society, where data holds a pivotal role, bodies are perceived as data producers regulating the demand for the buildings to be more efficient and functional at the same time. Consequently, these dynamics are contributing to the increased complexity in designing public buildings. Hospitals, as highly specialized and function-specific structures, are significantly impacted by the information society.

The focus of the graduation project is the development of a hospital tailored for a concept known as the 'Human Data Twin'. This project is based in Berlin and seeks to delve into the effects of digitalization in healthcare, specifically examining how datasets and artificial intelligence (AI) influence the architectural design and functions of hospitals. The term 'Human Data Twin' refers to a unique concept that requires further exploration, emphasizing the fusion of digitalization, healthcare, and innovative design principles in our project

The project holds significant relevance in the current context, drawing inspiration from near-future predictions of technological advancements in healthcare. The envisioned transformation from generalized to personalized and percision medication, facilitated by data science and technology, forms the crux of the project. By doing so, the project is poised to spark discussions around the imperative nature collaborating with technologies like Artificial Intelligence that will reflect change in the hospital functions, processes and design. This discourse will also shed light on ethical challenges and considerations inherent in such advancements. In a broader sense, the project aspires to establish guidelines for designing hospitals of the digital future.

Figure 1: (left)
The Oakland Municipal Auditorium is being used as a temporary hospital with volunteer nurses from the American Red Cross tending the sick there during the influenza pandemic of 1918, Oakland, California, 1918.
(Photo by Underwood Archives/Getty Images)

The poised problem

A century apart, two global pandemics share a common thread—seasonal viruses transmitted through breath, coughs, and sneezes. Despite the vast strides in medical innovation and information dissemination, millions of lives have been lost in both instances. This poignant parallel underscores the persistent challenges in combating infectious diseases and highlights the ongoing urgency for global health preparedness.

As per the Oxford Dictionary, a 'Hospital' is defined as an institution that provides medical and surgical treatment along with nursing care for sick or injured individuals. In this traditional hospital model of 'cure and care', individuals seek medical attention only when afflicted by illness, injury, or diseases. Hospitals play a crucial role in cities, serving as spaces for recovery, rehabilitation, and even the rejuvenation of human life, but all within its institutional boundaries *(figure. 3)*. The health datasets of individuals collected by hospitals are primarily used to understand the patient's medical history and address any immediate medical conditions. However, the health datasets hold the potential for much broader applications in information society, offering possibilities for holistic care preventing diseases, disorders, and undiagnosed deaths.

Despite Germany's worldwide reputation for advanced medical care, a recent study highlights that a substantial portion of deaths in the country is primarily attributed to progressive diseases caused due to changes in body metabolism. The onset of the COVID-19 pandemic also underscored the limitations of the 'cure and care' model, leading to significant loss of lives—both due to the acute illness of the virus and delays in detection, reporting and diagnosis. Hospitals that once used to be social institutions known for care are now merely perceived as healing machines.

Today, data is produced, processed, and consumed at every step. Individuals are placing a greater emphasis on their health and are willing to equip themselves with Internet of Things (IoT) devices, such as health watches or other body sensors, to keep track of their well-being. A study from 2021 shows that German health apps recorded a new high of 2.4 million downloads per quarter. Howver the health data generated by the IOT's does not have a recevier's end which can analyse, study and respond back with valued information *(figure. 4)*.

The demand for personalized healthcare and big data generation presents an opportunity for hospitals to establish a smart healthcare system, transitioning from a 'cure and care' to a 'care first' model, extending assistance beyond institutional boundaries.

Modern data management and Artificial Intelligence (AI) enable a comprehensive diagnostic approach, encompassing descriptive analytics for reviewing medical records, diagnostic analytics to analyze current conditions, predictive analytics for forecasting patient risks, prescriptive analytics suggesting treatments, and discovery analytics exploring unknown medical trends[1].

Technological strides now allow the digitization of the human body, forming a Human Data Twin (HDT) in cyberspace synced through an implanted IoT device. The HDT conducts real-time simulations, optimizations, and evaluations, providing personalized suggestions to empower individuals in making informed decisions, enhancing health performance, and extending life expectancy.

This healthcare transformation not only reshapes personal well-being but prompts a reevaluation of hospital architecture, signaling the emergence of institutions designed for the information age that recognise the interplay between data-driven healthcare advancements and evolving societal needs.

Figure 2: (right)
Staff members spray disinfectant at a residential community to prevent the spread of COVID-19 in Yuhua District, Shijiazhuang, north China's Hebei Province, Jan. 24, 2021. (Xinhua/Zhu Xudong)

1. Mohamed, K. (2018). Health Analytics Types, Functions and Levels: A Review of Literature. Data, Informatics and Technology: An Inspiration for Improved Healthcare, 137-140.
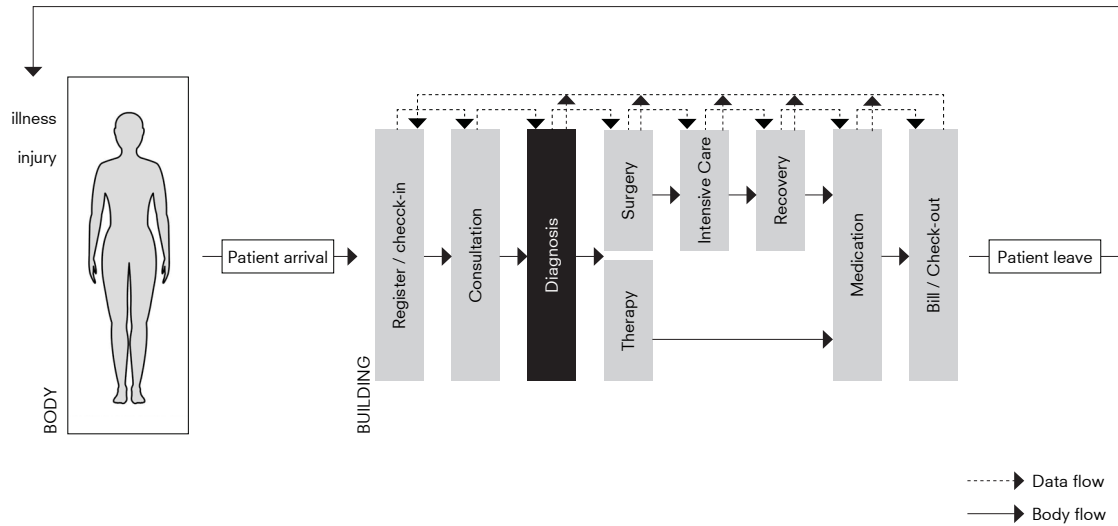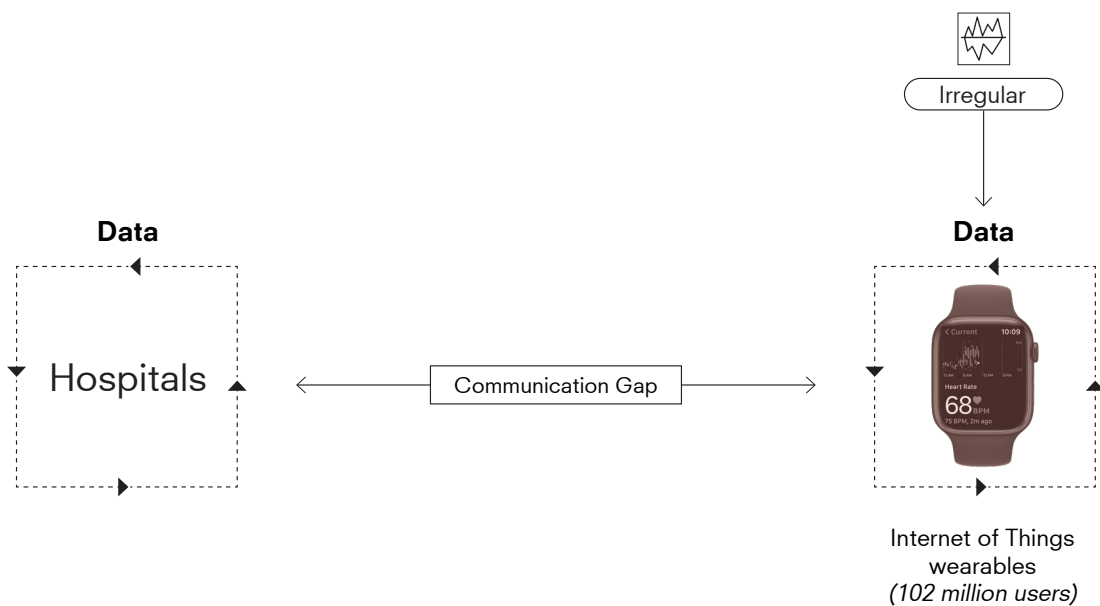
Figure 3: Cure & Care Model; *graphic by author*

Figure 4: Health data communication gap; *graphic by author*

Research Question

Hospitals, as public buildings, establish connections with people in ways unparalleled by other structures. The architecture of a hospital directly influences its functionality, exerting a profound impact on the delicate balance between life and death. In the contemporary information society, where the body is conceptualized more as a collection of data for tracking individuals' health, the pendulum shifts decisively toward life.

The transformative approach to healthcare through digitization has extensive implications, potentially necessitating the creation of new spaces within the hospital. Research indicates that the Artificial Intelligence revolution in medicine introduces new dynamics to spatial relations in the diagnostic process, where AI is likely to play a key role. The architectural design of hospitals also calls for reappraisal, presenting an opportunity to promote health, physical activities, and mental well-being of the society. The findings culminate into a research question:

How does the digitization of the human body in the information society, impact the architectural and spatial design of hospitals?

In this context, architecture investigates changes in form, functions, spaces, configurations, while spatial design responds to alterations in processes, arrangements, interactions, and flows.
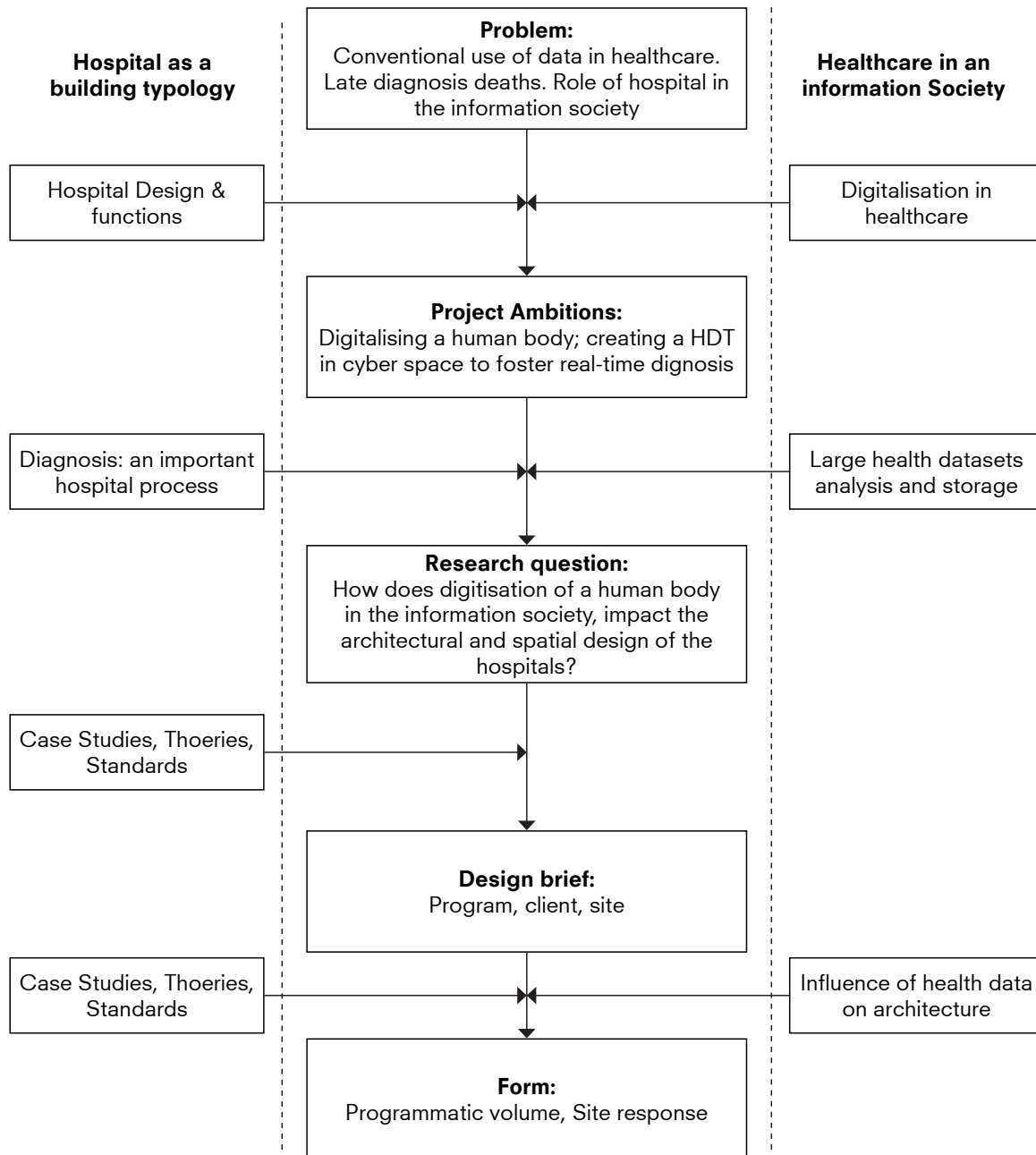
RESEARCH
FRAMEWORK

02

Hospital as a
building typology

Problem:
Conventional use of data in healthcare.
Late diagnosis deaths. Role of hospital in
the information society

Healthcare in an
information Society

Hospital Design &
functions

Digitalisation in
healthcare

Project Ambitions:
Digitalising a human body; creating a HDT
in cyber space to foster real-time dignosis

Diagnosis: an important
hospital process

Large health datasets
analysis and storage

Research question:
How does digitisation of a human body
in the information society, impact the
architectural and spatial design of the
hospitals?

Case Studies, Thoeries,
Standards

Design brief:
Program, client, site

Case Studies, Thoeries,
Standards

Influence of health data
on architecture

Form:
Programmatic volume, Site response

Figure 5: Diagram for Theoratical Framework; *graphic by author*

14

Theoratical framework

The research employs two lenses during the literature review to investigate:

1. Hospital as a building typology: This lens is utilized to understand hospital processes and functioning, examining the design evolution in terms of form, flows and efficiency.

2. Healthcare in an information Society: This lens explores the impact of digitalization and data on the functioning of public buildings.

In the book, "Hospitals: A Design Manual," the author describes the distribution of healthcare facilities, where centralization and decentralization strategies could be employed to create a hospital network, preventing the demolition of existing hospital buildings[1].

The theoretical framework *(see figure. 4)* aims to adopt methodological approach to understand the hopsital typlogoy from a city lens to the building scale.

Relevance

1. Early diagnosis: Studies show that late diagnosis and delays in reporting cause 75% of fatalities for cancer and other diseases.

2. Expert patients: With the rise of the Internet of Things, individuals are equipped with wearables that help them stay well-informed about their bodies. Studies show a rise in health download apps and an increase in telemedicine consultations.

3. Digital health care: The German Federal Ministry of Health is driving the digital transformation of healthcare system. The large health datasets will be governed by the government for security and an open data society, aligning with the goals of the Federal Ministry of Digital Infrastructure.

Research Methods

The graduation studio works simultaneously with both individual research and group research. A prevalent theme of digitalization is discussed and explored within the group, with the aim of formulating a digital strategy for Berlin. The research conducted by both the group and individuals mutually enhances each other's work, contributing to a shared outcome.

Program

Literature study

The literature study aims to gain deeper understanding of the key spaces, medical inventory used for diagnosis and treatments *(see figure. 6)*. It further aims to study different flows of varied users in a hospital evaluate the impact of digitalisation on it. The research also seeks to grasp the concept of the Human Digital Twin and the efficiency it can bring to the medical process.

Additionally, the study involves an examination of German and European guidelines for hospital buildings and current developments in information society.

Furthermore, within the group vision, there is an exploration of data centers and the role they play in an urban city, with the objective of identifying potential strategic changes for data centers. One proposed change is their inclusion in public buildings as architectural elements.

Case study

Benchmakring case studies will be undertaken to develop a progam for the hospital project, which wil also help gain a better understanding of the the spatial planning, and traffic flows in a hospital.

1. Wagenaar, C. e. (2018). Hospitals : A Design Manual. Walter de Gruyter GmbH. Retrieved from http://ebookcentral.proquest.com/lib/delft/detail.action?docID=5155807.

15

Key space study

The functions in hospital buildings are specific and require dedicated spaces. A thorough understanding of key spaces, such as operating rooms, examination rooms, and patient rooms, will be undertaken to implement necessary changes in this project. A key assessment of diagnostic processes, equipment, and functions will be carried out to gain better insights into these procedures, as the project primarily focuses on diagnosis.

Client

The project is envisioned as a public-private partnership to ensure equal authority over the data produced within the building. The client search will conducted over the internet and also by contacting the private partners to know more bout the technological advancements. The clients will be identifined based on the following requirements:

1. Technology for the future of medicine: Identifying pioneering companies dedicated to advancing Human Digital Twin (HDT) technology.

2. State owned hospital group: Given the need for widespread availability, a state-owned hospital group is sought to ensure affordability and accessibility of the services.

3. Data security: To align with open data objectives and ensure responsible data usage, the involvement of a federal ministry is deemed necessary.

Client Ambitions

As architects, we mostly design buildings for clients. This is why we need to understand the client and bring their ambitions to the table. This approach not only helps to generate interesting ideas for the project but also ensures that the design is functional for its typology .

Site

Mapping

A GIS mapping of specific datasets for Berlin will be layered to align with the three group site criteria for the urban vision. Additionally, three individual building typology criteria will be defined, and map layers for each will be produced. Based on the defined parameters, and superimposition of parameters layers, the three sites will be identified.

Site visit

A visit to all of the identified sites will be conducted during the studio excursion to Berlin. Photo documentation and mapping of site activities will be carried out.

Site analysis

The identified site will be analyzed in terms of its urban position, land use, connectivity to existing transport nodes, and current conditions. Given Berlin's rich historical presence, the site's history will also be examined to gain more insights into its usage. Based on this analysis, a strategy will be proposed for the site's development.

BIBLIOGRAPHY

03

References

1. Lee, P., Goldberg, C., & Kohane, I. (2023). The AI revolution in medicine: GPT-4 and beyond. Pearson.

2. Mohamed, K. (2018). Health Analytics Types, Functions and Levels: A Review of Literature. Data, Informatics and Technology: An Inspiration for Improved Healthcare, 137-140.

3. Nickl-Weller, C., & Nickl, H. (2020). Architecture for Health. Braun.

4. Li, A., & Shi, P. (2022). Research progress on wearable devices for daily human health management. Wearable Technology, 2 (1), 82 .https://doi.org/10.54517/wt.v2i1.1654

5. Riva , M. A., & Cesana, G. (2013). The charity and the care: the origin and the evolution of hospitals. European Journal of Internal Medicine, 24, 1-4. doi:https://doi.org/10.1016/j.ejim.2012.11.002

6. Shengli, W. (2021). Is human digital twin possible? Computer Methods and Programs in Biomedicine Update, 1, 100014.

7. Wagenaar, C. e. (2018). Hospitals : A Design Manual. Walter de Gruyter GmbH. Retrieved from http://ebookcentral.proquest.com/lib/delft/detail.action?docID=5155807.

8. Ramdurai, Balagopal. (2021). Use of Artificial Intelligence in Patient Experience in OPD. 1-8. 10.5923/j.computer.20211101.01.

9. Meskó, B., & Görög, M. (2020). A short guide for medical professionals in the era of artificial intelligence. NPJ digital medicine, 3, 126. https://doi.org/10.1038/s41746-020-00333-z

10. Puaschunder, Julia & Feierabend, Dieter. (2019). Artificial Intelligence in the Healthcare Sector. SSRN Electronic Journal. 10.2139/ssrn.3469423.

11. Rao, D. J., & Mane, S. (2019). Digital twin approach to clinical dss with explainable ai. arXiv preprint arXiv:1910.13520.

12. Capolongo, S., Gola, M., Brambilla, A., Morganti, A., Mosca, E. I., & Barach, P. (2020). COVID-19 and healthcare facilities: a decalogue of design strategies for resilient hospitals. Acta Bio Medica: Atenei Parmensis, 91(9-S), 50.

13. Heijink, A., van den Heuvel, J., & Schoonhoven, M. (2022). Increasing efficiency in healthcare: a showcase in an orthopedic outpatient clinic. International Journal of Lean Six Sigma, 13(1), 33-45.

14. Babbu, A. H. (2016). Flexibility: a key concept in hospital design. Int J Appl Innov Eng Manag, 5, 24-28.

15. Setola, N., Borgianni, S., Martinez, M., & Tobari, E. (2013, October). The role of spatial layout of hospital public spaces in informal patient-medical staff interface. In the Ninth International Space Syntax Symposium, Seoul: Sejong University.

16. Freihoefer, K., Nyberg, G., & Vickery, C. (2013). Clinic exam room design: present and future. HERD: Health Environments Research & Design Journal, 6(3), 138-156.

17. Lin, S. (2022). A clinician's guide to artificial intelligence (AI): why and how primary care should lead the health care AI revolution. The Journal of the American Board of Family Medicine, 35(1), 175-184.

18. Feenstra F. Reactivating Hospital, Active Patients Through Special Design. HERD: Health Environments Research & Design Journal. 2021;14(1):87-105. doi:10.1177/1937586720966757

19. Lacanna, G., & Wagenaar, C. (2018). Public Spaces in and Around the Hospital: Streets, Squares, Patios, Waiting Areas, Healing Gardens. In Hospitals: A design manual (pp. 61-64). Springer.