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DIS

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Exploring AI as a means of relating the body, digital information and the domestic space in the remote education process: Domestic Interactive System (DIS)

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Keywords
Architectonic interactive system; Cybernetics; Domesticity; Machine Learning.

Partner Institutions
Faculdade de Ciências da Universidade de Lisboa – FC_Ulisboa

Expected Future Partner Institutions
…

OBJECTIVES

Main: Develop an interactive support system for domesticity that takes AI-based computational models as a starting point, seeking to expand the possibilities of relationships between the body, the digital information, and the built space, and thus investigate ways of improving the experience of remote education.

Specifics: Relate authors and theories that support investigations of this nature (associated with Task 1); to establish an ethnographic approach through surveys involving FAUL students that allow us to perceive problems faced in the experience of remote education (Task 2); to develop a computer programming using the AI models that can support the mapped needs (Task 3); to elaborate the design of adequate physical space and representative of domesticity in the investigated environment (Task 4); to assembly and make compatible the physical structure and the computer structure - prototype (Task 5); to analyze students' interaction with the physical environment of simulation mediated by DIS, observing the application's strengths and weaknesses (Task 6); to understand how initiatives of this nature can contribute to the evolution of space and architectural design in the face of contemporary demands (Task 7).

BIBLIOGRAPHIC REFERENCES

Furtado, G., Moreira, I.: *Cartografias da Domesticidade*. In Jornal dos Arquitectos, Lisbon. no 203, pp. 96–103 (2001);

Pask, G. *The architectural relevance of cybernetics*. In Architectural Design, September issue No 7/6, John Wiley & Sons Ltd, London, pp. 494-496 (1969);

Portas, N.: *Funções e exigências de áreas da habitação*. MOP Laboratório Nacional de Engenharia Civil, Lisbon (1969);

Russell, S.J., Norvig, P., Davis, E.: *Artificial intelligence: a modern approach*. Prentice Hall, Upper Saddle River (2010);

Teyssot, G. *Hybrid Architecture: An environment for the prosthetic body*. Convergence, 11, pp. 72–84 (2005).

ABSTRACT + IMAGES

We can understand the domestic space as the primary architectural demand and the space with which most people develop more affinity (Furtado & Moreira, 2001). In the face of many of the impacts arising from the development of computing in the past century, the house has often behaved more as a technology shelter than a space that, somehow, incorporates aspects of digital evolution (Furtado & Moreira, 2001).

Since the 1950s, some architects and researchers believe that improving the relationship between architecture and the computer is possible. In this sense, we highlight Gordon Pask's (1928–1996) approach in the article *The architectural relevance of cybernetics* (1969). The article points to contributions from cybernetics, generally understood as the study of communication between man and machine, which can be helpful in a systemic view of architecture, where *feedback*, *goals*, and *loop* become relevant mechanisms.

The understanding that domesticity is reflected in the spatial organization of the house, where activities and functions usually have specialized spaces (Portas, 1969), allows us to develop an approach centered on the inhabitant from the spatial determination of certain activities. Our general hypothesis is that some contemporary activities in the domestic sphere, such as remote teaching (for example), can be facilitated through a systemic approach. The body is related both to the domestic environment and to digital information simultaneously. This relationship takes advantage of the blurring of concepts seen as opposites in the past (public and private, natural and artificial, etc.), allowing the emergence of devices that can act together with space to develop a prosthetic relationship with the body (Teyssot, 2005). In general, we have already experienced a certain degree of visual interaction in the domestic space, described in our paper *Toward a digital window* (2020), which part of this can be briefly observed in Figure 1.

Among so many computational biases possible to collaborate with the spatial experience of architecture, we believe that Artificial Intelligence (AI) is a very encouraging branch of computer science. Since that term was coined in 1956 in the famous conference held at Dartmouth College, AI has come up with solutions based on mathematical models that assist in solving problems that require some intelligence (Russell et al., 2010). Among the main branches of AI, we highlight Machine Learning (ML, with a solid statistical approach) and Natural Language Processing (NLP) as the most promising strategies for the type of interaction intended. As an example of possible applications of AI in domesticity, we present in Figure 2 a general scheme of an application that we developed (*room_ID*), which can recognize the primary domestic environments through ML neural networks (we described the development process in our paper *room_ID: An architectonic image classifier tool correlating machine learning and the domestic space*).

Supported by the relationship between domesticity, cybernetics, and AI, we have as the main goal to develop an interactive domestic system (DIS) based on specific needs of the inhabitant, which can be helped through the relationship of the domestic space with digital information (see Figure 3). In this way, we hope to contribute to improving the remote teaching experience as a medium (without addressing issues related to the content, which is not our focus).

The methodology is diversified and wide-ranging, and is structured in interrelated stages: 1) literature review, focusing on the three main concepts mentioned above; 2) ethnographic cutout with part of the FAUL academics, with the application of surveys; 3) development of a programming for the application capable of meeting the intended questions, especially that of responding to the demands mapped in the previous step, and that is open, to allow future uses in other contexts; 4) design and planning of the physical environment of the testing and evaluation prototype, where a conventional domestic environment is simulated (a living room, for example); 5) execution of the physical environment of the prototype; 6) testing and evaluating the DIS with students in the environment developed in the previous steps; 7) maturation and final analysis of the process and the data obtained, which allows us to produce a scientific article, submit an application for the FCT call for IC&DT projects, and apply for a patent regarding DIS application.

The confluence of these apparently diverse subjects, nevertheless connected with contemporary demands, permits us to establish an innovative approach. The DIS application is significant for the specific contributions of helping the remote teaching experience in the home environment (which can help both teachers and students) and stimulating other investigations that perceive the creative potential of the relationship between architecture and AI.

Figure 1 - visual interaction in the domestic space

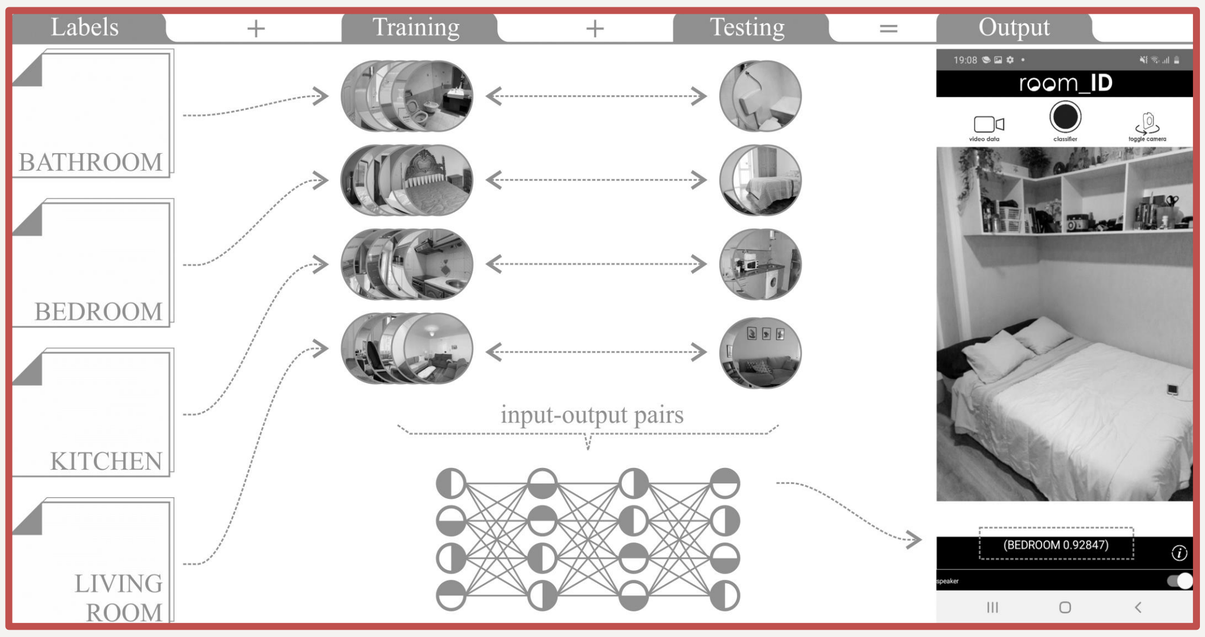

Figure 2 - general scheme of *room_ID* application which can recognize the primary domestic environments through ML neural networks

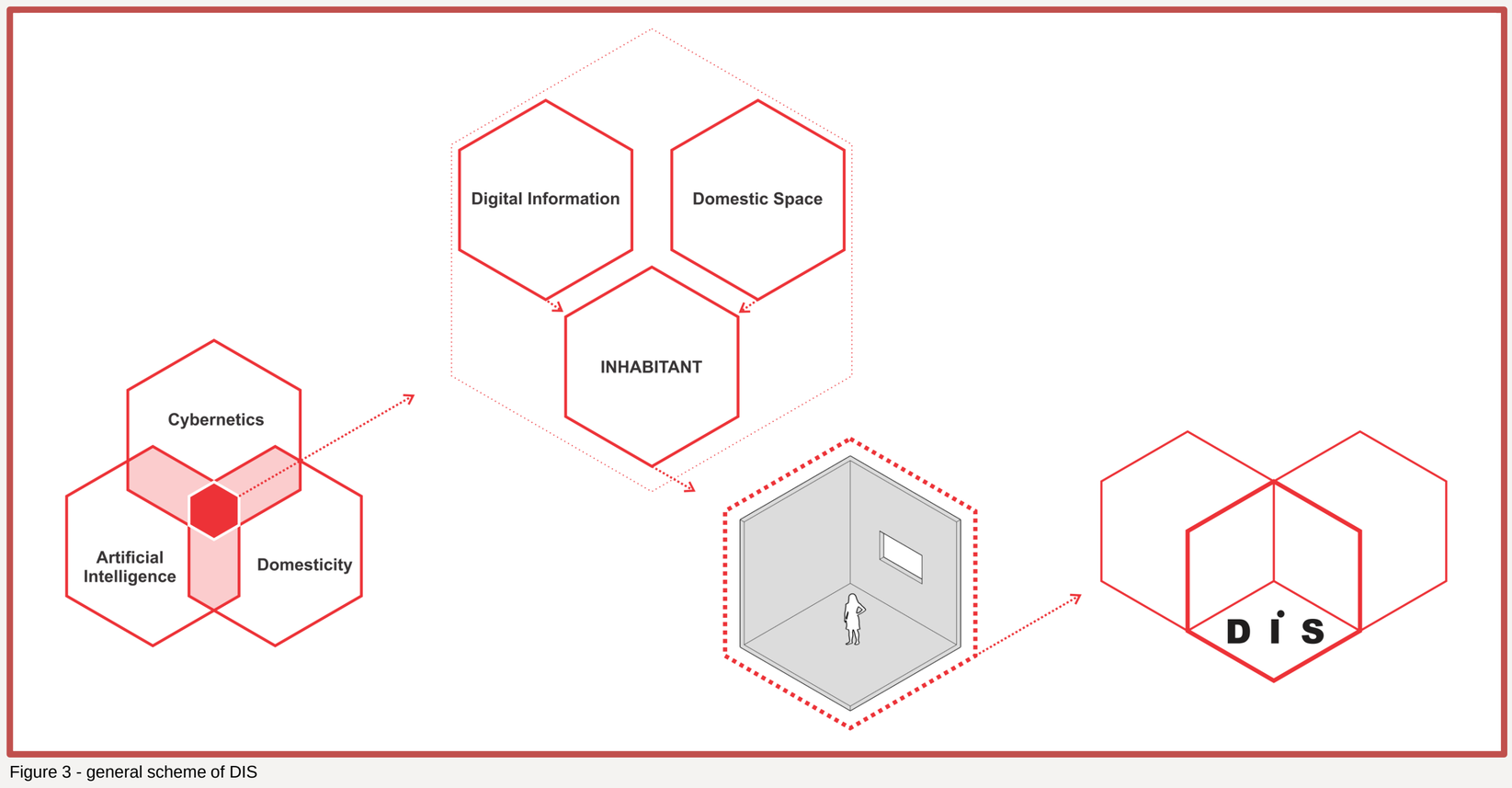

Figure 3 - general scheme of DIS

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SCIENTIFIC RELEVANCE FOR THE DISCIPLINE

The search for an answer capable of collaborating with the performance of specific activities and functions in the domestic environment through AI is an innovative path, and that at the same time is in line with a certain “tradition” of architectural research (Archigram, MIT Media Lab, House N, Media House, among others). In this context, we still believe that the development of an open system to support contemporary domestic demands is of scientific relevance. In the case of this project, we turn expressly to the issue of remote education. However, the DIS understood as an open system can be adapted to meet other particular demands, such as home care in childhood, issues related to population-aging, physical limitations specificities, etc. Due to this bias, the DIS can also be understood as a design system, as someone can reconfigure it in several ways, where the relationship between body, domestic space, and digital information can benefit the inhabitants.

EXPECTED ECONOMIC AND SOCIAL IMPACT

In general, we hope to collaborate with the development of technologies aimed at domesticity that can also guide other projects with compatible ambitions in addition to meeting the objectives proposed here. Consequently, we expect to develop an interaction apparatus between the body, the domestic space, and digital information to improve the experience of remote education. We intend with such apparatus to support needs felt in contemporary living, and which, as apparatus, may have its theoretical basis and technical procedures serving as support for other domestic issues posed in contemporary times. Both economically and socially, there is great potential in this approach, seeking to offer students in remote education situations alternatives that can improve this experience, making it more sensitive and integrated into the home space. This potential expands when we understand DIS as an open system that can also be adapted to other domestic needs.

RESEARCH PLAN AND TASKS

TASK 1 - ESTABLISHMENT OF A THEORETICAL BASIS

Objective - To provide a literature review appropriate to our scope and objectives;

Description – To study authors who support the three main concepts addressed: cybernetics, domesticity, and AI. In addition to the few authors already cited in the *Bibliographic References*, we initially included some other authors such as Norbert Wiener, Heinz von Foerster, Usman Haque (cybernetics), Philippe Aries, Sandra Marques Pereira, Witold Rybczynski (domesticity), Helder Coelho, Rodney A. Brooks, Gary Marcus (IA). This theoretical construction starts from cybernetics as a systemic approach that allows relating, in a broad sense, the field of architecture with AI. Our approach focuses on domesticity and contemporary implications, such as remote education in a more specific sense. In parallel, we will investigate AI and its methods as a strategy to assist the experience of remote teaching while dealing with digital information;

Duration - This task is continuous and parallel to this entire project; however, it happens more intensely in the first three months.

TASK 2 - ETHNOGRAPHIC CLIPPING

Objective - To understand how the experience of remote education has been taking place in the domestic context, through statistical data referring to FAUL academics;

Description - This stage provides for the preparation, application, and analysis of data collected through surveys. Students from FAUL compound our analysis group. To establish this frame, we will apply the survey in classes of two academic chairs. At first, we will invite all academics from the classes mentioned above (we expected a number between 40 and 60 participants). Such participation is voluntary;

Duration - This task is planned and structured in parallel to Task 1, but its execution takes place in the fourth month; during the fifth month, we analyze the information collected that will directly imply in Task 3.

TASK 3 - SOFTWARE DEVELOPMENT AND COMPATIBILITY

Objective - To develop programming for the application capable of meeting the demands and ambitions of the DIS;

Description - This intended programming seeks to converge and make compatible in the same architecture/structure several algorithms already developed that let us work with ML and NLP, among other possibilities that we can find. Therefore, it is already possible to mention that we intend to take advantage of good practices already established in the area. Algorithms already developed on the *Keras*, *TensorFlow*, *Pytorch*, *Teachable Machine*, and *MIT App inventor* platforms, among others, will be analyzed, and, when desirable, we will incorporate them into the programming. In this stage, we have foreseen advice from IT professionals to assist this task. We report such assistance in the “Budget” section;

Duration - This task develops more concentrated from the fifth to the seventh month; however, from this point on, it does not end since constant changes and updates are expected, as the DIS is implemented and tested.

TASK 4 - PLANNING THE PROTOTYPICAL PHYSICAL ENVIRONMENT

Objective - To design and plan the execution of an installation that simulates a typical domestic environment into FAUL’s dependencies;

Description - Based on information obtained in Task 2 (ethnographic survey) and considering the domestic recurrence in the development of the remote teaching activity, we will design a physical environment with the capability to simulate a “common” domestic environment. This project also considers issues related to materials and ease of assembly and execution, since it is an installation to be done inside the FAUL building, using light and accessible materials (such as cardboard and Styrofoam, for example), with parts developed and produced employing digital fabrication (through *the LPR - FAUL Rapid Prototyping Laboratory*). In this context, we intend to take advantage of temporary furniture already existing in FAUL, except for the equipment expected to be acquired and described briefly in “Budget”;

Duration - This task will be carried out in the seventh month, parallel with the last month of the previous stage.

TASK 5 - SETTING UP THE PHYSICAL SIMULATION ENVIRONMENT AND THE COMPUTER APPARATUS

Objective - To install the physical simulation environment, as well as the computer structure that supports the spatial implementation of DIS;

Description - After obtaining permission to assemble the installation (preferably in one of the covered halls and close to the students' studios), we will assemble the structure on wooden sheets produced using the *CNC Milling Machine*. The closings will be carried out with the light materials previously described (there will be no need to worry about the weather, as it will be an internal installation protected by the existing building). A simple electrical installation takes place from the outlet points on the floor of the FAUL’s blocks. We will support the simulated environment with the furniture available at the college, to which we will add the electronic devices acquired with resources from this support source;

Duration - This task will be carried out in the first half of the eighth month, immediately following the previous step.

TASK 6 - TEST OF USE AND OBSERVATION OF THE INTERACTION

Objective - Analyze how the interaction between the body, the physical environment, and digital information proceed;

Description - In this stage, after the first use experiments with relative success carried out by the team itself, we begin the phase of inviting students to test the system. We will observe this use in a simulated environment, followed by a survey that aims to analyze the usability criterion, seeking to map the strengths and weaknesses, which will permit us to improve the DIS approach (return to Task 2). At this stage, we again invite and encourage the voluntary participation of all students of the two classes. This interaction will be essential for us to evaluate how the DIS behaves, its success concerning its interactive approach, and how the system can be improved. We emphasize that part of this step is to map the system's difficulties. Hence, we are expecting problems. The main contribution of this task is precise to allow us to understand what are these failures that we need to face;

Duration - We expected this task to last up to one month, and if the previous one succeeds, we expected it to be completed by the end of the first half of the ninth month.

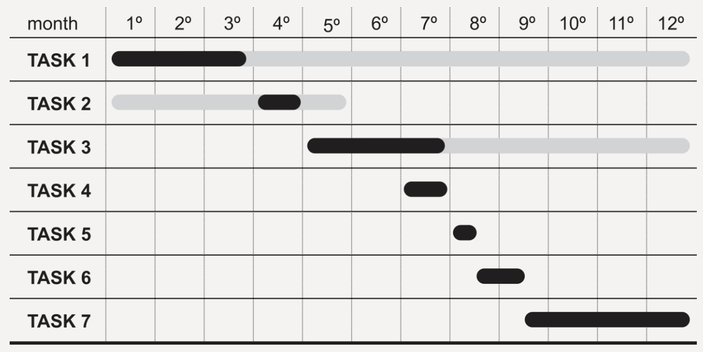
TASK 7 - FINAL CONSIDERATIONS

Objective - Analysis and synthesis of all processes developed;

Description - In this last stage, we intensify the analysis of the activities developed in all the previous stages, the consolidation of results achieved, data collected, and we elaborate a general synthesis based on this set of information. This synthesis will be translated into a scientific article (to submit it to a publication with indexing) and will provide the basis for applying to the FCT call for IC&DT projects; and the initial application for the registration of a DIS patent.

Duration - This task ends our schedule, going from the second half of the ninth month to the end of the twelfth month.

These tasks follow the schedule:



EXPECTED SCIENTIFIC RESULTS

- The development of a computer system (an application) capable of helping the relationship of the body with digital information in the domestic space;
- The collection of data and survey of the problem related to remote education in the context of the use of domestic space for such purpose, and the subsequent validation through the evaluation group, also composed by FAUL students.
- The registration and organization of this process as a whole, its theoretical bases, the development of the application, the data collected, and the results obtained in a scientific article, and submit it to a publication with indexing (ISI or Scopus);
- From this endeavor, propose and apply the FCT call for IC&DT projects or another similar call;
- To allow that the equipment and the physical simulation environment can be used in FAUL’s master’s and doctoral research, as long as they share common ambitions;
- To create a patent application for the system in question (DIS).

BUDGET: € 7.500,00

“D) Acquisition of other goods and services;”

- Goods: Computer = up to € 1,500; tablet = up to € 350; projector = up to € 2,000; Materials and supplies for the execution of the prototype (such as cardboard, Styrofoam, digitally manufactured parts, etc.) = up to € 500. Total expected in the acquisition of goods: 4,350 €;
- Services: Consultancy in programming with an IT professional = up to € 3,000.
- Expected total with purchase of goods and services = up to € 7,500.

We justify acquiring the goods mentioned by the need to assemble the hardware apparatus to support the system under development (DIS), as well as the execution and assembly of the physical environment of the testing and evaluation prototype. The need for advice from an IT professional is to fill any gaps concerning system programming, compatibility between different programming languages and ensure that development uses the most appropriate support software, among the wide variety offered to developers in this area.