MODELLING A NEW WORKFLOW BASED ON EMOTIONAL ANALYSIS OF FLOOR-PLANS USING MACHINE LEARNING ALGORITHAMS AND SEMIOTICS

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Abstract

The initial purpose of technology is to aid us in repetitive tasks. For example, in recent years, CAD programs are helping Designers to spend more time on the Design itself; being limited by the tool seems like a distant memory. Designers can generate complex forms and plans for their design, however, like our predecessors, we are still open to all kinds of mistakes. With the emergence of Artificial Intelligence, not only we can make machines do a specific task for us, but also learn to guess, predict, and plan for the future and avoiding the same mistakes over (Tech Innovations to Help Manage Project Data and Create New Ways of Designing, 2018). Specifically, Machine learning (ML) is a field of artificial intelligence that uses statistical techniques to give computer systems the ability to "learn" (e.g., progressively improve performance on a specific task) from data, without being explicitly programmed (Stuart Russell and Peter Norvig, 2009).

As Architects, we are all responsible for what we design and carry out, even further, we are responsible for the effects which our Buildings render into the world. Therefore, in Academia, we approach design as a practice of refinement, it's a process of Generating Alternatives and testing them, over and over, until finding the final option. This is Indeed, very similar to the way an automated machine works except machines are without human error. With the help of our current technologies, we can train machines to learn the design process and aid us in various tasks such as planning, optimization, and prediction for the outcome.

One of the most fundamental aspects, regarding the design of a building, is the process of generating plans based on user's needs; in which many factors are actively affecting the process. Many factors drive the generation/design of an architectural plan and Our Emotions towards a specific space is one of the important ones, which mostly and often dismissed by the Designer. By applying AI to this process; which follows the same principles; the designer is constantly supported by a recorded knowledge that can help him design avoiding such mistakes (Embracing artificial intelligence in architecture, 2018).

Our creative goal is to develop an A.I, which can make a dialectic between the designer and the user's emotion, making the design more efficient for the user. The research aims to find hidden relationships between the factors which shape a floor plan and the user's emotions; and finding a balance point to establish a new Workflow. The first step to do so is to train a computer program, which learns the relation between our emotions and the design, the latter can be achieved using machine-learning technics, provided with data sets of floor-plans, powered by semantic networks.

Key words: Artificial intelligence; Emotional analysis; Patterns in Floor-plans; Bias in the Design Process; Semiotics in Design

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1. Introduction

1.1   Emotional Bias in the process of design

From the earliest days of our architectural practice, we have been thought to be responsive towards users need, to design flexible spaces for them to carry on life. This comes very simply as common sense when we want to design a simple House; for instance, the living room is a place socialize, be peaceful and co-exist with our loved ones. There are numeral Activities relating to these needs such as eating, talking to each other, playing games, watching TV … etc., which are a manifestation of our same core desires. But in the first place, why are we inclined to these types of activities, in a living room. There are many factors playing a constant roll in the way we design, one of the factors is about what we have agreed to call a "house" so far, for thousands of years, when we commit to the idea of a house. This is called Semiotics. Each word in a language is a construct by which we have agreed to this specific way of-referring, to inculcate our desires and emotional needs. (The Origin of Consciousness in the Breakdown of the Bicameral Mind, 1976) (Elements of semiology, 1968).

Figure 1. **The relation between The sign, Signifier and the Signified**
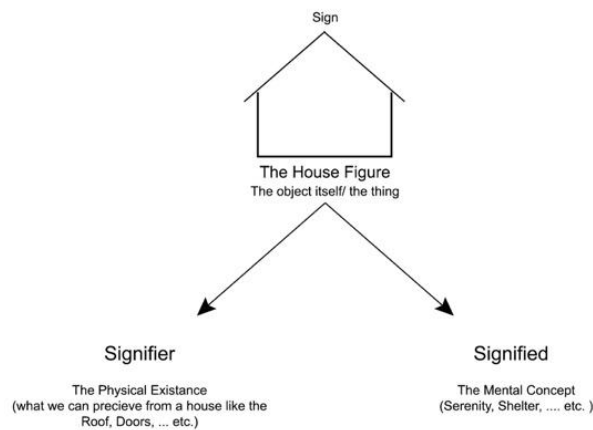
Source: Elements of Semiotics

For Instance, the emotional function of a "Home" is to fulfill several basic essential desires; Shelter, Safety, Serenity, and Family (The Signified); but Again, how do we really know this? When we think of a home, we think through the language system we speak, which links our memories labeled as "the home". Partly, the first matter comes into play are actually those emotions towards the "house" figure, whether we are aware or not *(Man, and his symbols, 1978)*. We do not possess a memory which happens in no-where, after all, we call the function of a space based on what we normally do in the very space; A "living" room, A "dining" room, A "bath" room, or As a Matter of fact, generally all "rooms" have *actions* associated to their names.

Immanuel Kant was a leading philosopher in 19th century, who contemplated on the philosophy of mind most of his life; in his first book, "Critique of the Pure Reason" he mentions the importance of the space where any experience happens:

"Space then is a necessary representation, a priori, which serves for the foundation of all intuitions."

Our actions in a specific place are always linked to the function of that very space. When the function of the place is served, other factors start interacting with the user's experience. One of the most important parts of any experience is our *emotions towards the place. We always exist in a place while we think therefore it is prior to our thoughts (Immanuel Kant's Critique of pure reason, 1781).*

Christopher Alexander, is a widely influential British-American architect, mathematician and design theorist, who wrote several books on hidden factors driving the design process. He is one of the first scholars who tried to make a generative grammar for the Design culture, a way to show that there are active psychological components in the design process which are not being paid enough attention but still affecting us. (The nature of order, 2004; Patternlanguage.com, 2019).

In order to create a workflow for the emotional analysis of floor-plans, first we need to define and classify our emotions so we can breakdown architectural functions (for example a living room) with their correspondent core emotional representatives (The signified); in the other words, we need to explore our basic emotions towards each rooms function thoroughly.

1.2   Basic emotions

Considering emotions are always limited to be experienced subjectively, many definitions have been suggested. Here is a definition from a neuroscientist's point of view: "The term emotion should be rightfully used to designate a collection of responses triggered from parts of the brain to the body, and from parts of the brain to other parts of the brain, using both neural and humoral routes."

Emotions have been categorized several times in different ways, each one serves as a new way to classify it. Paul Ekman has been working on the matter of emotions for more than 40 years. He stated we have six basic emotions: Anger, Disgust, Fear, Happiness, Sadness, and Surprise. Later, another researcher, named Robert Plutchik, added two basic– emotions to this list and elaborated a geometrical diagram called the wheel of emotions, as shown below in figure 2. (Plutchik, Robert ,2003)

Figure 2. **Robert Plutchik's Wheel of Emotions**
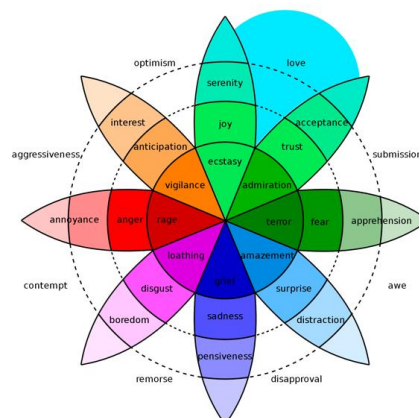
Source: Plutchik's Wheel of Emotions: A Guide to Understanding Emotion, 2019.

This diagram is used by psychologists for psychoanalysis. There are several properties embedded in the diagram:

-It suggests 8 main emotions (8 sides of the circle, the main circle in the center divided by 8 lines), which originally are 4 main states, mirrored based on their emotional counter-part (look at figure 2): (note that A! =B meaning A is Not B)

- Loathing! =Admiration.
- Rage! =Terror.
- Grief! =Ecstasy.
- Vigilance! =Amazement.

For example, the state of ecstasy and grief both are manifestations of the same state, but one is positive and the other one known to be generally negative; they are also located opposite to each other. Simply imagine one is in a negative state of remorse, knowing its positive counter-part is the state of love, we can nullify the negative by exposing one to positive (love).

Another property this diagram suggests is that more complex States are a synthesis of two counterpart emotions. For instance, the state of "Awe" emerges by the synthesis of two main emotions: "terror" and "amazement" (figure 3).

Figure 3. **Emotional counter-parts, the example is for the state of Love and Remorse**
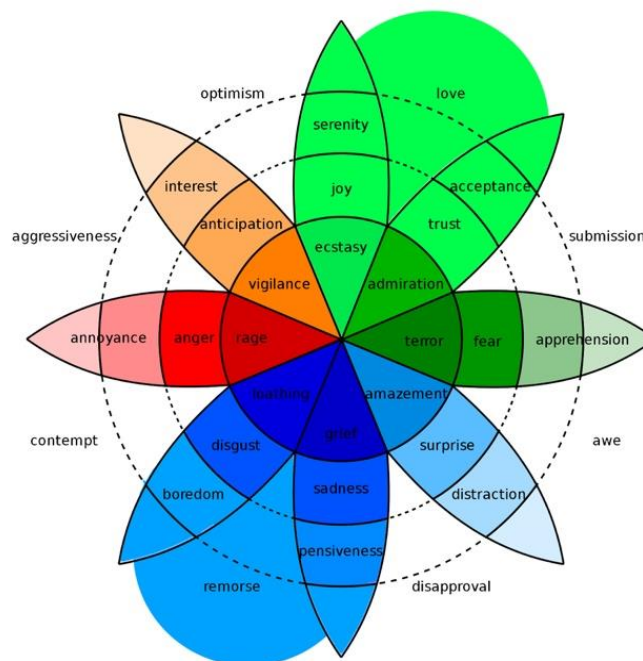
Source: Plutchik's Wheel of Emotions: A Guide to Understanding Emotion, 2019.

1.3   Emotional analysis of the spaces

With the help of this diagram, we can analyze the emotional function of a place, as a recognizable sequence of emotions, been caused by the way that place have been designed.

Our Emotions are profoundly connected to the context where they first emerge. An "Entrance"(the sign), for instance, is always a "door"-like figure (the signifier), by which we decide to transcend from what we know, to the state of unknown (the signified). This very notion is recorded by our brains and stored when we were an infant, for the first time, experiencing "entering" to "another place". As it is mentioned before, the "entrance" sign, relates to many "signifiers" but its "signified" meaning contains the very sense of it; we ar architects always try to interact with that very sense in order to create pleasant moments for the new users. considering that, when we are designing an entrance, we want to convey the sense of being welcome to a new place; Likewise, a basic "meeting" room must imply the idea of work and progress, accompanied by a peaceful sense of co-existence. Observing the diagram, we notice a "work" place is correspondent to emotions of "submission", "love" and "optimism". One might have many other emotions at a given moment, but these 3 emotions (for this example) are the *most fundamental* to where the main action of "work" happens. They are a root to more complex emotions.

In our case study for a simple house, sub-spaces may be composed of these basic emotions:

- Entrance:

"Optimism", "Acceptance",
" Awe", "Vigilance" (self-awareness) and "Trust".

- Bathrooms:

"Submission" (since taking care of our body is an act of submission to ourselves), "Vigilance" and "Anticipation" (from one's self).

- Kitchen:

"Submission", "Anticipation", "Joy" and "Vigilance".

- Living room:

" Love", "Acceptance", "Serenity", "Ecstasy", "Joy", "Optimism" and "Apprehension".

- Bedrooms:

"Serenity"," Love", "Acceptance", "Admiration", "Joy", and "Optimism".

- Balcony or Privet Yard:

"Optimism", "Acceptance", "Serenity", "Ecstasy"

This is not a fundamentally new method, but is a conscious one, by which we categorize places based on the emotions we want to trigger in that space. As there are thousands of examples from the history of architecture, our goal for the design has always been being responsive to user's states and shape their emotions interactively. But we do the latter unconsciously and that makes our work render un-desired reactions. Before the modernization of architectural design, one of the main reasons to design and build enormous *monumental* Cathedrals, was to interact with the user's emotions, positively or negatively.

2. Methods used in emotional analysis approach

Regarding what was said before, this is indeed a phenomenological approach. The main tool in such conducts is probabilistic models. We can incorporate our emotional analysis method into a probabilistic computer program, so we can interactively design a place based on the user's emotional feedback.

These are five main stages to develop the workflow:

I. Designing a simple test for inquiry from architects (Bias test), and processing the statistical data extracted from the inquiries with a computer. This can be used as a reference, later. Also another type of a psychological test can be elaborated to evaluate users' emotions towards the "house" figure.

II. With the help of Machine Learning algorithms, we train a program, which detects and store different elements of an architectural plan (Windows, Doors, Function of the rooms, …, etc.) (figure 5),

III. Using Convolutional Neural Network[2] and the help of inquiry-driven data, we can associate each emotion, to a specific plan function, for instance, a door or the living room.

IV. Refining the parameters (since it's a probabilistic model, values and weights are relative and need further practical investigation.).

V. The main goal is to create a simple Convolutional Neural Network, by which, we can analyze and visualize the interactions between the user's emotions and the design of the house, accordingly.

The initial step is to create simple diagrams which a machine (a computer program) can learn from it, and stores the relative data. We can demonstrate the first step by a series of very simple tests shown to the students and Architects (two plan and section outlines presented below the tests, been created as a simple diagram and serve no other purpose):

- Which plan outlines shown below is more positively interactive and relatable with the idea of "Serenity" for the users?
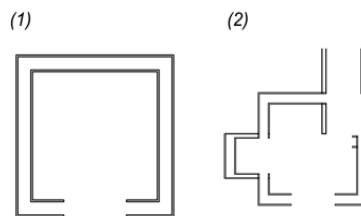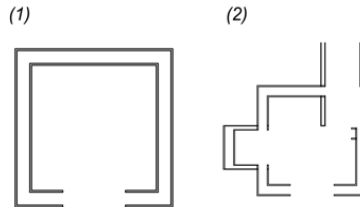

- Which plan outlines shown below is more positively interactive and relatable with the idea of "Safety" for the users?


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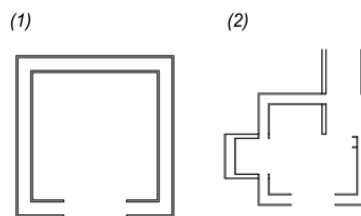
[2] A convolutional neural network (CNN) is a specific type of artificial neural network that uses perceptrons, a machine learning unit algorithm, for supervised learning, to analyze data. CNNs apply to image processing, natural language processing and other kinds of cognitive tasks. A convolutional neural network is also known as a ConvNet. (https://www.techopedia.com/definition)

- Which plan outlines shown below is more positively interactive and relatable with the idea of "Trust" for the users?

- Which plan outlines shown below is more positively interactive and relatable with the idea of "Vigilance" for the users? (Self-Awareness)
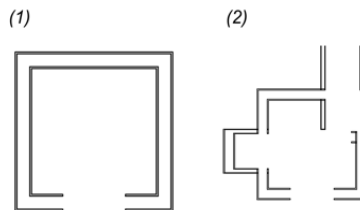
- Which plan outlines shown below is more positively interactive and relatable with the idea of "Submission" for the users?
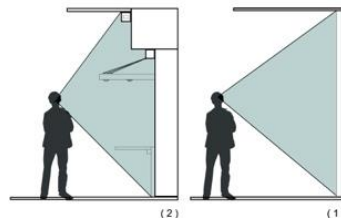

As we can observe ourselves answering to these tests, we notice possessing a certain inclination towards one of the answers in each test. That very *bias* is one of the main subjects in our study. Later we can store these data, and Use them as a value for the "bias" of a Convolutional Network (CNN) which later will aid us to analyze floor-plans more efficiently.

3. Results

Following the same workflow, these analyzations may help us reveal hidden relations between our psyche (character, one's self) and what we design. In prospect, we may develop a simple CAD program which inputs a pre-designed emotional map by an architect, and as outputs, it - generates architectural drawings based on machine learning (ML) and image-processing algorithms (figure 5). This can enhance emotional aspects of our design; in a way we could never imagine. This research may help architects design a house, where it is accurately tailored for its own users' emotional needs towards a "house" figure.

Figure 4. **Diagram shows the process of categorizing functions of the different places in a house, using Neural Networks and Machine Learning**
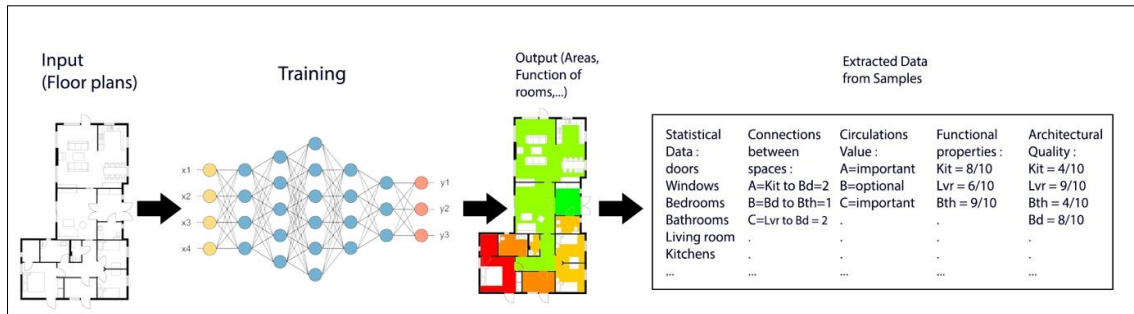
Source: Authors.

Figure 5. **An example for how we can analyze and feedback floor-plans based on what our design may communicate and express to users emotionally**
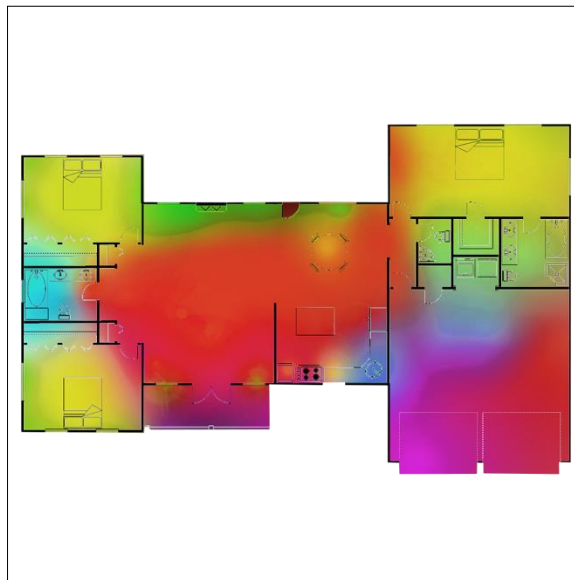
Source: Authors.

The effort is to explore possibilities of a psychological-technological approach to the design, to thoughtfully sequence, analyze and predict possible emotional interactions in a house, computationally. To investigate and design each room/ space based on its most demanding emotional counterparts regarding the users need in that very space.

The prospect of the research is to explore the interconnections between emotions and room functions, to develop a program which we can generate floor-plans based on users evaluated emotions and data.

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