A Computer Model for Novel Arrangements of Furniture.

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Abstract. This paper reports a computer program that generates novel designs of arrangements of furniture within a simulated room. Although it is based on the E-R computer model of creativity, the current prototype only implements the engagement part. In this document we explain the core parts of the program and how we build our knowledge structures. We present some experiments, conclude that our program is able to generate novel arrangements of furniture, and describe some future work.

Keywords: *engagement-reflection, designs, emotional reactions, tension, context, atom.*

1 Introduction

The spatial arrangement of furniture within a room influences individuals' behaviour and emotional reactions. For example, people tend to classify furniture as belonging to specific areas within a house. In this way, when we walk into a bedroom we expect to find a bed, a television, a closet, probably a desk, etc.; all these elements belong to the set of bedroom-furniture and therefore we can think of them as establishing what we refer to as a harmonic relationship. In the same way, we might be surprised (an emotional reaction) if we find within a bedroom a washing machine. Since the washing machine does not belong to the set of bedroom-furniture, the harmonic relationship between the elements inside the room is broken leading to an individual's emotional reaction (e.g. surprise, stress). The elements that comprise the set of bedroom-furniture, or the set of kitchen-furniture, etc., and the types and intensity of individuals' emotional reactions depend on cultural, traditional and economical aspects.
There are several approaches to the research of the relation between emotions, behaviour and physical spaces. For example, Pullman and Gross [1] studies how to create emotional nexus with guests or customers through careful planning of tangible and intangible service elements within a business; what they are interested about is in analyzing emotional responses as mediating factors between the physical and relational elements that conform customers' experience, and their loyalty behaviours. Ritterfeld [2] points out the importance of the functional value (being used for specific purposes) of quotidian objects as an essential part of the process of aesthetic impression formation in daily life. Mehrabian and Diamond [3] studies how specific arrangements of chairs influence the way a conversation takes place. Lang [4]

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studied how teachers in high-school alter the classroom-space in order to achieve their pedagogical goals.
We have developed a computer model able to represent emotional reactions to a specific arrangement of furniture within a room and then, following the engagement-reflection (E-R) computer model of creativity [5], employ this emotional representation to guide the generation of novel arrangements of furniture. The E-R model has been successfully employed to develop a computer program for plot generation known as MEXICA. Its main characteristics are:

- The user provides a set of examples that are employed to build the system's knowledge structures.
- The model includes two core processes: a generation process (known as engagement) and an evaluation processes (known as reflection). During engagement the system generates material guided by content constraints; during reflection the system evaluates the material generated so far —modifies it if it is necessary— and as a result of the evaluation adjusts the constraints that drive the generation of material during engagement. The system's outputs are the result of the interaction between engagement and reflection.
- An important characteristic of the model is that, following Gelenter [6], emotions are the glue that link ideas during engagement. Thus, in MEXICA, emotional links and tensions between characters drive the generation of material during the unraveling of the plot [7].

The main purpose of this work is to explore if the ideas that inform the E-R model employed for building MEXICA can be applied in interior design (see Alvarado & Pérez y Pérez in this proceedings for an example of the use of the model in music; see Acosta & Pérez y Pérez [8] for an example of the use of the model in creative problem solving). We believe that the study of the commonalities and differences in the use of the E-R model in different domains might result in interesting information about computational creativity. The program we report on this paper only implements the engagement part of the E-R model (we are in the process of designing the reflection part). It has two possible operation modes: user-mode and design-mode. The user-mode provides an interface that represents a room and ten pieces of furniture. The user can employ the interface to generate several designs of arrangements of furniture. The system records this information to create its knowledge-base. The design-mode generates automatically a novel arrangement of furniture. In this work, a novel arrangement of furniture means a design that is not recorded in the system's knowledge-base. It is out of the scope of this paper to perform any study related to individual's emotional reactions to spatial arrangements of furniture. Therefore, for the present version of the program, we intuitively define a set of rules that establish three types of possible reactions. However, our model is able to deal with a wider variety. In the following lines we describe the room and household goods we work with, how we represent emotional reactions and how the user and design operation modes work.

2 Description of the Room.

The current version of program works with the representation of a single-room (see figure 1). The room is defined as four walls surrounding an area of 3x3 meters. We identify two different types of positions within the room:
Centres. The room has five centres: the positions located at the centres of wall-1, wall-2, wall-3 and wall-4 are represented by the symbols c1, c2, c3 and c4 respectively; the centre of the room is represented by the symbol c.
Corners. The four corners in the room are represented by the symbols e1, e2, e3 and e4.

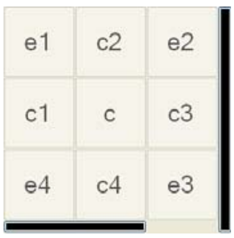

Fig. 1 Representation of a room.

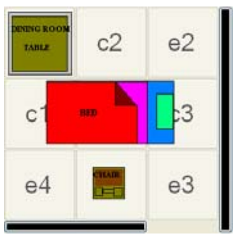

Fig. 2 An example of arrangement.

The current version of our program includes a list of ten possible pieces of furniture to be employed: a bed, a dining-room table, four single chairs, a vase (which is considered as one piece of furniture), a couch, an armchair, and a small-coffee table. Thus, it is possible to locate the table on e1, the bed on c and the chair on c4. The user can select the direction that each piece of furniture has; e.g., the bed can be located on c pointing towards the east (see Fig. 2).

3 Description of Tensions and Knowledge Structures.

We refer to the representation of emotional reactions to an arrangement of furniture as tensions. We distinguish three types of tensions: *Tension of Utility (Tu)*, *Tension of Proximity (Tp)* and *Tension of Distribution (Td)*.

Tension of Utility (Tu). In our model, furniture is designed to serve a purpose. For example, the purpose of a chair is that a person sits on it; the purpose of a bed is that a person lies on it (and probably sleeps on it); etc. In our model, when the utility (purpose) of a piece of furniture is affected, the system triggers a Tension of Utility. In this way, if a chair is situated on the bed, which implies that neither the bed nor the chair can serve its purpose anymore, the system detects this situation and triggers two Tu (one for each piece of furniture); if the chair is removed, both tensions are deactivated.

Tension of Proximity (Tp). In our model, the distance between each individual piece of furniture must be at least 10 centimetres (with the exception of the chairs located by the dining-room table). Thus, if the user locates a chair in front of a coffee-table side by side, a Tension of Proximity is activated. In other words, when two or more pieces of furniture are too close to each other (less than the equivalent to 10 centimetres) the system triggers a Tp.

Tension of Distribution (Td). In our model, it is important that the furniture is evenly distributed around the room. For example, if a bed is situated on e2, a chair on c3 and a table on e3, only the right part of the room is occupied. All the left part of the room has no furniture and therefore looks strange. So, if the system detects this situation, it triggers a Tension of distribution. We decided that a piece of furniture situated at c does not trigger a Td.

In the current version of the system, all tensions have a numerical value established by the user. Thus, we can calculate the value of the tension produced by a specific arrangement of furniture in the room. Figure 3 shows three possible arrangements of household goods. Figure 3.b shows a *vase* on the floor at c, a *bed* on the floor with its head pointing towards the north at c_3 (it invades e2 and e3 due to its size and orientation), a *chair* on the bed at c_3 and armchair at c1 pointing towards the west. This arrangement triggers the following tensions: two Tensions of Utility (Tu) due to the chair on the bed (the bed cannot be employ to sleep and the chair cannot be employ to sit; each tension has a value of 4); a Tension of Distribution (Td) because positions e1, c2, e4 and c4 are empty while the rest contains (at least part of) a piece of furniture (this tension has a value of 4). This arrangement generates a tension = 12.Thus, it is possible to describe a specific room-design in terms of its furniture, their position in the room and the tensions they produce. We refer to this description as *Context*. So, the Context of figure 3.b is comprised by: a *vase* on the floor at c, a *bed* on the floor at c_3, a *chair* on the bed at c_3, an *armchair* on the floor at c1, two Tu due to the chair on the bed and one Td due to four empty positions. *Context is an important part of our model since it is employed during the generation phase (engagement) as cue to probe memory and retrieve a possible action to continue the design of the room*.

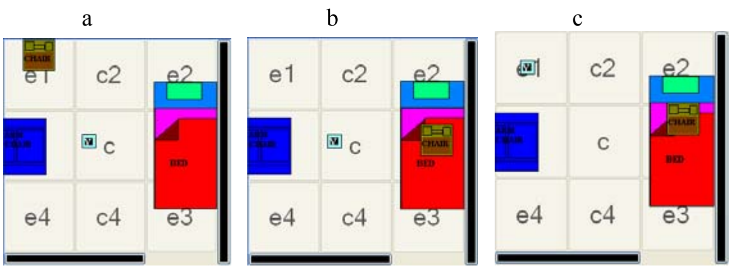

Fig. 3 Three possible arrangements of furniture within a room.

In our current model, it is possible to generate two types of designs: calm and tense. A calm-design has a Tension < 10, a tense-design has a Tension > 10. We associate a calm-design with a conventional disposition of household goods within a room; we associate a tense-design with an unorthodox disposition of household goods which attempts to produce an emotional reaction in those individuals that watch into the room.
The design process implies to generate a sequence of different arrangements of furniture until the right one is found. For example, figure 3 shows a sequence of three different household goods dispositions. The Context of Figure 3.a, named as Context1, is comprised by: a vase located at c, a bed located at c3, a chair located at e1, and an armchair located at c1; a Td is generated because positions c2, e4 and c4 are empty. In figure 3.b an action has been performed to modify this design: the chair has been located on the bed. This action produces a new context (described some lines above) named as Context 2. In figure 3.c a new action has been performed: the vase is moved to e1. This action produces a new context in this example named as Context 3. The final design has a tension = 12 so, it is classified as a tense-design.
As an important characteristic of our model, we link contexts with possible actions to perform; e.g. Context1 is linked to the action "put the chair on the bed"; Context2 is linked to the action "Put the vase on corner e1" In this way, we are able to generate sequences of actions during design by associating different contexts (see Section 4). However, because contexts describe very concrete situations and the E-R model requires more general representations, we transform contexts into what we refer to as *Atoms*. An atom is a context where all concrete objects (e.g. table, bed) and their positions in the room (e.g. e1, c3) are substituted by variables. In this way, Context1 and its linked action are transformed into Atom1:

Atom1: Object1 is located at cX, Object2 is located at cY, Object3 is located at eX and Object 4 is located at eY; Td= 3 (because three quadrants empty).
Linked Action: Object3 is put on Object 2.

Object1, Object2, Object3 and Object4 are variables that can be instantiated with any furniture; cX and cY are variables that can be instantiated with any center; eX and eY are variables that can be instantiated with any corner. The linked action indicates that Object3 must be put on Object2. Notice that the relations between objects and locations are kept and each variable represents a different element. *Thus, the goal of this project is to associate Atoms (sets of tensions and furniture-locations relations) with possible actions to perform. Then, employ this information to generate during engagement novel arrangements of furniture*.

4. General description of the system

As mentioned earlier, our current prototype only implements the engagement part of the E-R model. The system has two main processes: building the knowledge structures (atoms) and the design process (engagement). Engagement employs atoms to generate novel designs.

Building knowledge structures. In order to generate atoms we have developed a computer application to perform a design process (user-mode). This application shows a representation of the room and the furniture that we described earlier. The user can perform any of the following actions: put a piece of furniture on any of the defined positions; eliminate a piece of furniture from the room; move a piece of furniture from one position to a new position; put a piece of furniture on top of another piece of furniture; change the orientation of a piece of furniture. The aim of this program is to permit the user to generate different designs. The program records user's actions and generated contexts, and employ these information to build its atoms.
Engagement (design-mode). The user can ask the system to generate a tense or a calm design. In a tense design the system employs actions that increase the tension; therefore, actions that decrement the tension are considered as not useful. In a calm design, the system employs actions that increase the tension and then actions that decrease the tension. During the decreasing phase, actions that increment the tension are considered as not useful. Engagement works as follows:
1. An initial arrangement of furniture (a seed) is provided to the system by the user.
2. The system calculates the positions of the furniture and the tensions they produce in order to update the Context.
3. The context is employed as cue to probe memory. The goal is to match all those atoms that are at least 50% similar to the context (this parameter is known as the ACAS-Constant and can

be modified by the user. Its purpose is to give the system the possibility of matching atoms that are not identical to the Context. In this way, novel designs emerge. See Pérez y Pérez 2007). The system retrieves all actions linked to the matched atoms.
4. Those actions that are not useful for the design in progress are eliminated. From the remaining actions one is selected at random as the following action to continue the design.
5. The system goes back to step 2.
The cycle ends when an impasse is declared (no atom can be matched), when a predefined number of actions have been performed or when a predefined value of tension is reached

5. Experiments and Discussion.

To test the model we provided the system (employing the user-mode) with eight different tense-designs and calm-designs. Then, we asked the program to generate designs which were original (different to those that we provided) and which were either tense or calm. The system was able to accomplish the task. Figure 5 shows an example of the steps that the program followed to develop an original tensional design.

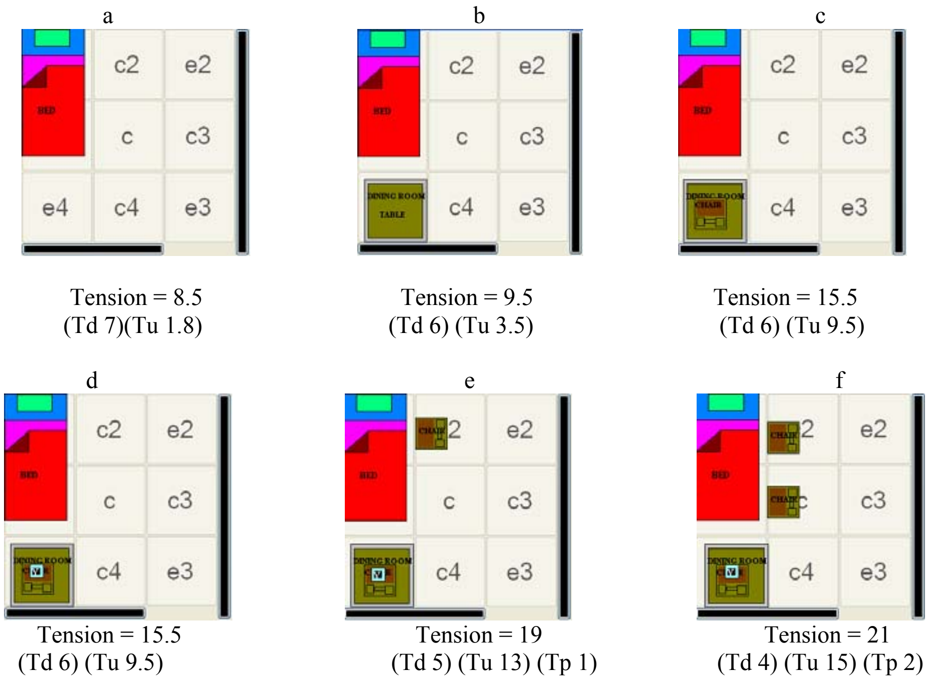

Figure 5. Steps to produce a tensional design.

The bed on the upper-left corner was provided by us as the initial context (see figure 5.a). Then, based on the experience recorded in its knowledge-base, the system surrounded the bed with furniture that increased the tension (a table with a chair and a vase on top of it, and two chairs located too close to the bed). That is, the system locates the furniture in the room based on its previous experience (not at random) and is able to satisfy the requirement of generating a novel arrangement which produces tension. In other experiments, when we set the ACAS-Constant to a high value (e.g. 90%) the system starts copying previous designs (instead of creating novel ones) and impasses are easily declared (i.e. the system cannot match any atom). This is congruent with previous results [7].
This paper reports a work in progress. Based on the E-R model, we have developed the engagement part of a program that generates novel arrangements of furniture in a room. To achieve this goal, we defined how to represent emotional reactions to furniture arrangements, and how to build Contexts and Atoms (set of tensions associated to actions). In this way we have shown that: 1) the engagement part of the E-R can be employed to generate original

dispositions of household goods in a restricted domain; 2) representations of tensions can be employed to guide the design process.

These are just initial results. We expect that once we implement the reflection part, where the material produced is evaluated for novelty and interestingness, and if it is necessary the material is modified by the system, our results will improve. That is, we will be able to generate more interesting designs. In the same way, we plan to extend our work by including more types of tensions, more furniture, as well as adding features like illumination and colour to the room and household goods. We believe those elements play an important role in the appraisal of emotional reactions.

We hope this work encourages people to study the role of emotions in the creative process.

> In the 1980s, in writing The Design of Everyday Things, I didn't take emotions into account. I addressed utility and usability, function and form, all in a logical, dispassionate way—even though I am infuriated by poorly designed objects. But now I've changed. Why? In part because of new scientific advances in our understanding of the brain and of how emotion and cognition are thoroughly intertwined. We scientists now understand how important emotion is to everyday life, how valuable. Sure, utility and usability are important, but without fun and pleasure, joy and excitement, and yes, anxiety and anger, fear and rage, our lives would be incomplete. [9]

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