Designing Posters Towards a Seamless Integration in Urban Surroundings: A Computational Approach

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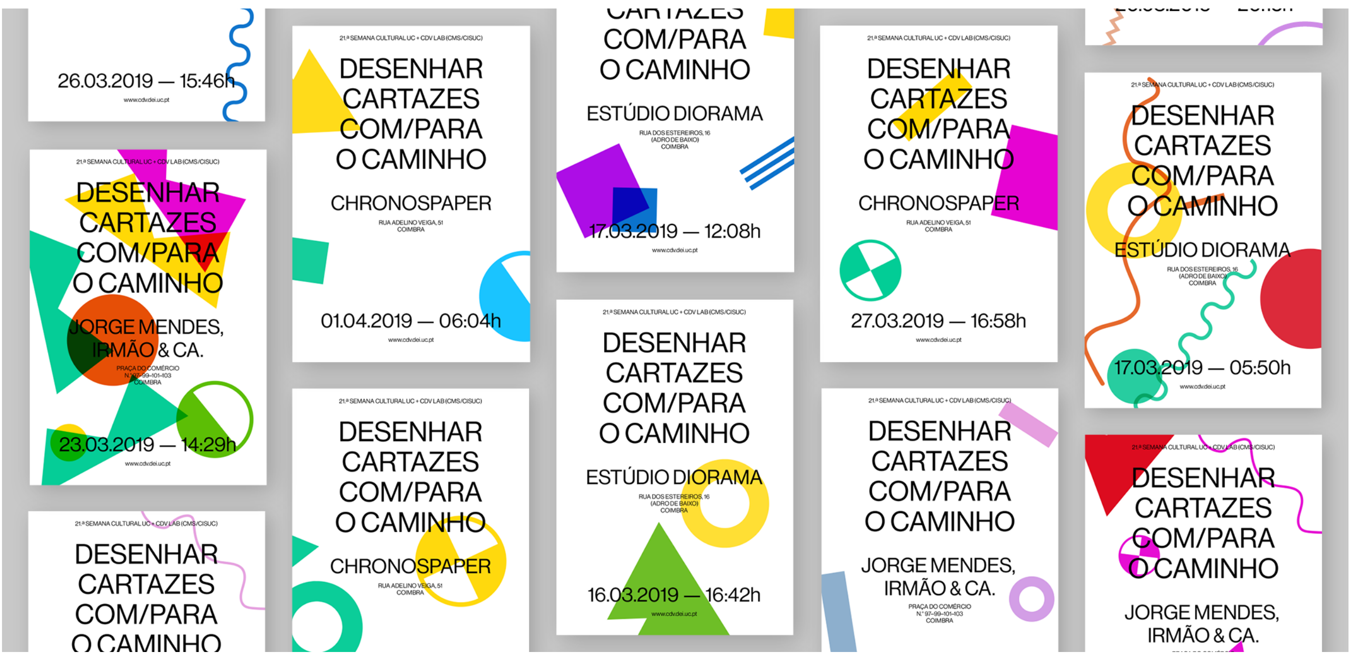

Figure 1: Poster designs generated by the installation.

ARTECH 2019, October 23–25, 2019, Braga, Portugal

ACM ISBN 978-1-4503-7250-3/19/10…$15.00
https://doi.org/10.1145/3359852.3359900

ABSTRACT

Posters have always played a key role in the living fabric of our societies. They are the most noticeable form of communication in urban settings, wielding great influence in the interpretation and perception of a place by passers-by. Seeking for a poster that seamlessly integrates into the urban environment, we developed an interactive installation that employs a computational approach to design posters. The installation generates poster designs according to the feedback that it gathers from the surrounding environment. This way, it designs posters for the site where it settled and, at the same time, according to the data gathered from the environment near it. In this process, it uses computer vision techniques and contextual-aware data to read the environmental conditions. Also, we give it the capability of evaluating the generated outputs and learning through its previous experiences. In this sense, the installation system, over time, begins to understand which is the best way to design in line with the data that it gathers from the environment. We set up the installation into Coimbra's historic centre, for four weeks, to perceive its behaviour. Furthermore, we conducted testing sessions with users to assess the outputs generated.

CCS CONCEPTS

• Human-centered computing; • Applied computing→Arts and humanities; Publishing; • Information systems → *Multi-media information systems;* **• Computing methodologies →** Computer vision;

KEYWORDS

computer vision, context-aware computing, computational design, interactive installation, graphic design, poster design

ACM Reference format:

Sérgio Rebelo, Catarina Pires, Pedro Martins, João Bicker, and Penousal Machado. 2019. Designing Posters Towards a Seamless Integration in Urban Surroundings: A Computational Approach. In *9th International Conference on Digital and Interactive Arts (ARTECH 2019), October 23–25, 2019, Braga, Portugal.* ACM, New York, NY, USA, 11 pages. https://doi.org/10.1145/3359852.33599001

1 INTRODUCTION

Posters have been, and remain, a fundamental agent in people's everyday life decision-making [7,29]. Their roots lie in cave paintings when ancient humans drew utilitarian and ritualistic messages on walls, with educational purposes. Already during the Roman Empire times, messages were painted on wooden panels and placed in streets to announce notices, political campaigns and services [10,16]. However, technological and social advances during the Industrial Revolution (in the first half of the nineteenth-century) deeply changed the nature of posters [5]. Unlike ancient posters — designed to a precise place with a precise message —, the Victorian posters were designed to be easily reproduced. This way, they multiplied and spread themselves over the urban environment [8,18]. Nowadays, they still are a palpable aesthetic presence in our cities' landscapes, constantly calling upon the passers-by throughout their different colours, positions and sizes [8,26]. Consequently, posters became a key element in the perception of social dynamics from an environment by passers-by.

The recent advances in computer science are reflected in all spheres of our society. Graphic Design (GD) and Visual Communication are no exception. Technological innovations do not only reformulate creative tools but also the way people relate to designs [3,6,23]. In the poster design scenario, for instance, we observed the emergence of novel digital media that resembles poster designs, but also allows the inclusion of video and/or interactions elements — the *Moving Poster* [4,25]. Everyone agrees that these media have considerable expansion potential. In the near future, more complex computational techniques will be used to generate designs that enable seamless participation with the audience [11]. In this sense, Computer Vision techniques (CV) and Contextual-Aware Data (C-AD) may be key tools in future poster design practice.

Exploring the potential of these technologies in the poster design scenario, we developed an interactive installation that employs a generative design process to design posters. The posters are generated using a system capable of translating data, gathered in physical surroundings near the installation, in poster designs. Also, this system can learn how to design posters based on its previous experience. Besides designing posters for a specific site, the installation also designs posters according to data and feedback collected in the surroundings of the same site. This way, it tries to generate posters that seamlessly integrate within the environment where it is placed.

In a brief way, the system works as follows. Each poster is composed of visual elements. Each visual element is placed in the composition with a set of visual and placement features associated with it. To define these elements CV techniques and C-DA are used. Each visual element is placed with a lifespan associated. The lifespan decreases every time that it stays in the composition unless it is rewarded. A reward maintains/increases the visual element lifespan. The reward is assigned based on the interaction between people and the installation. To define the rewards, we see the installation's surroundings, employing CV techniques, to measure: (i) the number of people near installation; (ii) the distance between the people and the installation; and (iii) the number of people attentive/interested in the installation's outputs. Moreover, the system has the ability to assess its outputs and to learn with its previous experiences. To assess its outputs, the system constantly calculates the composition fitness based on the data gathered from the environment. Furthermore, it is constantly examining if the current output is the most suitable for the current environmental conditions. Over the runs, the system replicates outputs (or part of them) that previously had good evaluations in similar environmental conditions, i.e. it begins to design posters for the place where it is settled.

We set up the installation in the urban environment in order to study its behaviour. We placed it on Coimbra's Historic Centre (CHC). This neighbourhood enabled us to place the installation in streets with different environmental conditions and people fluxes. It was installed for four weeks in the store windows of four different stores, a week per shop. After, we tested the resulted outputs with different people to understand: (i) if the system is able to translate the data gathered from the environment in outputs; and (ii) if the system's learning capabilities are noticeable on the outputs.

The remaining of this paper is organised as follows. Next section presents some related work. Section 2 comprehensively describes the approach to design the installation software and hardware. Section 3 describes how the placement of the installation is done. Section 4 displays the outputs resulting from the placement of the installation and the conclusions deduced after the testing sessions with people. Finally, Section 5 draws the conclusion and points the future work.

2 RELATED WORK

With the establishment of the computer as graphic designers' main tool, digital technologies progressively started to be explored in the GD scenario [3,14,23]. In the poster design scenario, we have already seen posters designed using visual element generated through code. It is notable, for instance, the experiments of John Maeda for Morisawa type-foundry (1996) [15], the posters for *The Puddle* designed by Gysin-Vanetti (2001) [9] and the visual applications of *Poetry on the Road* event designed by Boris Müller and one/one (2001) [19]. More recently, it is also notable the *Programming Posters* of Tim Rodenbörker (2018) [24] or the *Evolutionary Typographic Posters* of Rebelo et al. (2018) [21].

In the last few years, we also noticed the growth of the *Moving Posters* [4,25]. However, most of these posters are only animated versions of a poster and, therefore, they are not an interesting matter in the context of this work. We are only interested in works that, in some way or another, enable the audience to influence the poster design. Studio Feixen's posters for *Oto Nové Swiss Festival* 2017 [27] and 2019 [28] are good examples of this. This posters moving versions are web-applications which enable the user to interact through the mouse. Although the set of interactions are predefined, the way users interact with the poster is always different.

The *Post-Print Project* (2017) [17] enables a more interactive and engaging poster visualisation experience for the viewer. In this regard, augmented reality is employed to unlock a new layer of information with animations and 3D objects. This layer could be viewed using a mobile device and a specific mobile application in custom-designed posters. Like in Studio Feixen's works, the posters' elements animation is always the same, however, the way that user see the posters are always different.

The installation *Blowing in the Wind* (2014) [1] designed by Åkestam Holst, for the Swedish pharmacy chain Apotek Hjärtat, gets information from the environment where it is placed, without directly requesting human action. The installation outputs were an interactive poster that reacted to incoming trains. It used ultrasonic sensors to get data about the surroundings (e.g. distance to the incoming train). These data were then used to tousle the hair of the model in the poster [30]. In 2016, Åkestam Holst designed the *Coughing Billboard,* also to Apotek Hjärtat [2]. This installation used infrared sensors to check if someone in front of it is smoking. If it detects someone smoking, the central figure in the poster coughs.

The upward trend to create designs that react to environmental stimuli have unveiled that CV techniques may have the main role in the design of posters in the future [4,11]. *Camera Postura* [13] developed by LUST, for Netherlands Film Festival 2014, is a good example of this. The installation tracks the viewer's gestures and seeks similar scenes poses in popular movies at the festival. Following, the matching scene is used as poster background. To create a poster, the selected background image is then combined with additional information about the movie chosen by the system [20]. Rebelo et al. (2017) [22] also explored CV techniques according to the same perspective . They developed an interactive poster that through a computational design system converts the audience's position (captured using CV techniques) in visual transformations on the elements that compose the poster. Beyond that, C-AD it is also used to define the colours employed by the system. Lopes et al. (2018) [12] also employed CV techniques to generate "dancing eyes" for the poster of *Olhos Music Fest*. They developed a system that detects people's eyes, in an inputted image, and moves a copy of them around its original position according to the rhythm of an inputted song (i.e. song amplitude).

Figure 2: Installation prototype inside of a store during the experimental setup.

3 APPROACH

This work is based on the idea of developing a generative design system that designs posters that lives together with the ubiquity of cities posters, adapting itself to the surroundings where it is placed. Moreover, we are interested in developing methods that enable the system to understand, over time, what is the most efficient way of designing according to the site where it is placed.

We developed this system and built an interactive installation to hold it. Figure 2 displays the developed installation prototype placed in a store window.

An output of this system (i.e. a poster) is composed of two structural components: (i) template parts; and (ii) visual elements. Template parts are pieces of information that are immutable over the generations and, therefore, are not affected by the environmental data. On the other hand, visual elements are autonomously created by the system and affected by the environmental conditions around the installation over its runs.

When we start the system, it displays a composition only with the template parts drawn. Throughout the runs, it adds visual elements, with multiply as blending mode, to the composition. Each kind of element is grouped into separate layers. It generates the final output combining the two layers (see figure 3). The visual elements remain in composition until they overpass their lifespan. The data gathered by the installation's surroundings is used to define the visual elements' features, and to evaluate the outputs generated by the system. The system reads the surrounding around the installation gathering data in two ways: (i) directly, i.e. through direct environmental readings, namely via sensor reading and CV techniques; and (ii) indirectly, i.e. through C-AD readings, namely via access to geo-referenced data in external data collections.

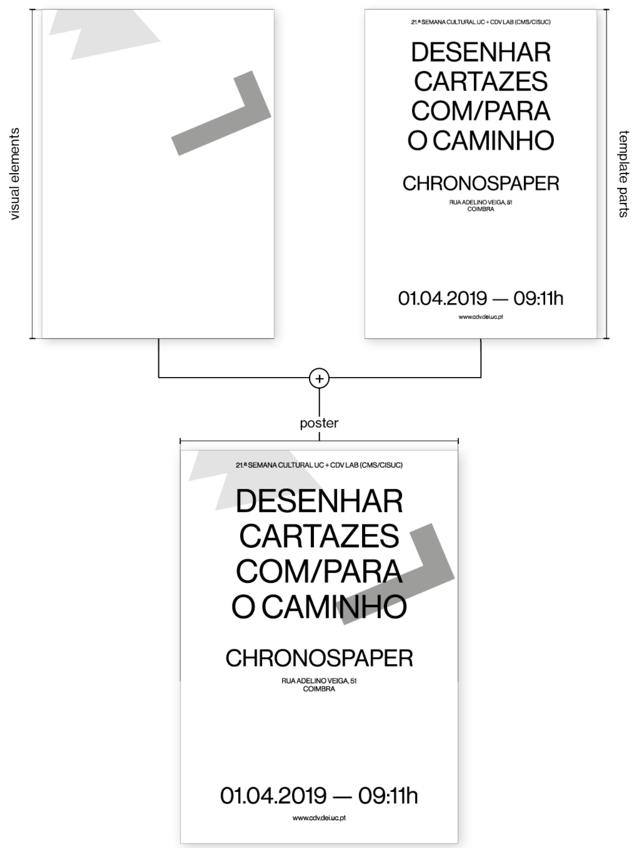

Figure 3: Scheme displaying how the final outputs are generated. An output generated by the system is designed by superimposing two layers. One with the template parts and another with visual elements.

The system has the capacity to save and to manage history entries. This enables the system to employ techniques to create outputs based on its previous design experiences. In this sense, for each generated composition the system creates an history entry in the file. This history entry contains: the descriptive version of the output; the current state of the environment; the raster version of the output (PNG image); the vector version of the output (PDF file). Also, this enables the system to redraw the outputs and/or simulate a specific environmental condition.

The installation was materialised using a single-board computer connected to a monitor (that displays the current output), to a web-camera (that captures the environment) and to a photoresistor sensor (that reads the environment luminosity levels). Figure 4 displays the blueprint of the installation's hardware.

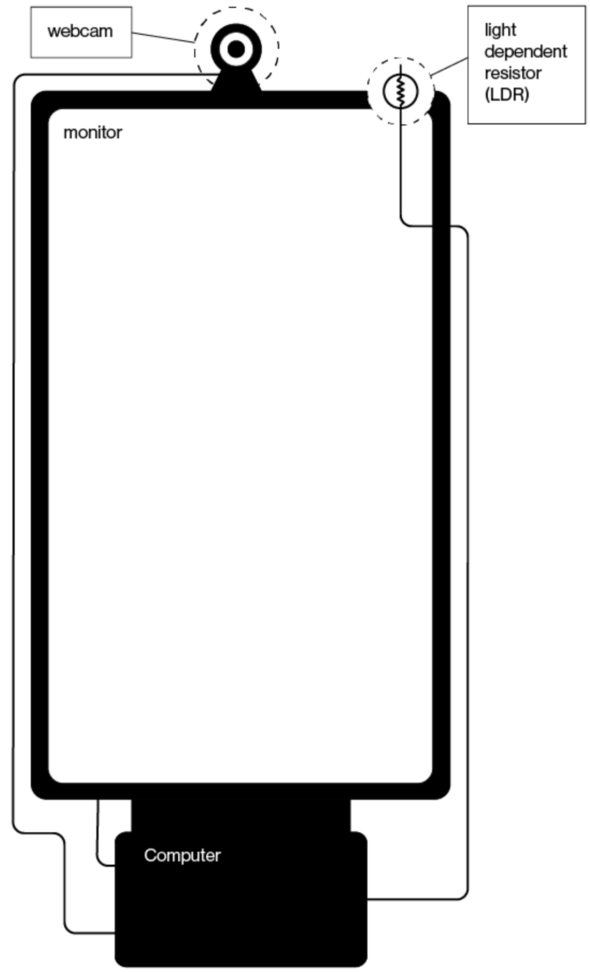

Figure 4: Blueprint of the installation's hardware.

The system generates the outputs fulfilling three main tasks: (i) the elements generation (see subsection 3.1); (ii) the outputs' fitness assessment and reward (see subsection 3.2); and (iii) the placement of the visual elements (see subsection 3.3). The next subsections comprehensively describe each one.

3.1 Elements generation

As mentioned above, the system generates outputs by superimposing two layers, one with template parts and another with the visual elements.

The template parts are defined in the core of the system. Their visual styles are therefore conserved during the successive system runs (e.g. typeface, position, and colour). Nevertheless, their content can change dynamically over each run. Consequently, the template parts are only used to transmit information, related to installation or/and the outputs generated, in a textual way (see figures 1 and 3). It includes unchanging contents related to the system development (e.g. the sponsors or technical information about the installation) and dynamic contents related to the place where the installation is settled (e.g. the placement address or the current date and time). Although sometimes the content of template parts may vary, we do not consider their as visual elements because they can be rendered by the system without an environmental reading.

On the other hand, visual elements are created and placed, by the system, in an autonomous way. Their generation is restricted by settings defined, beforehand, in system core. The restrictions include the base shapes (either shapes or images) and the base colour palette. To define these restrictions, the system dynamically loads the data in a specific folder on the file, in the beginning. Shapes are stored directly in this folder (either in raster or vector format). Colour data is stored in a text file in the same folder (either in RGB values or HSB values). This enables us to easily modify the basic features of visual elements without change the system core. Also, it allows anyone, or other generation systems, to contribute to this system with new assets.

Before generating a visual element, the system defines its visual features (i.e. shape, colour, scale, and rotation) and placement features (i.e. position and lifespan). The system begins to define the visual element's appearance. First, it chooses the visual element shape selecting one from among the shapes loaded beforehand. After, it decides the visual element colour hue based on colour temperature factor. This factor is used to subdivide the basic colour palette (loaded beforehand from file) in a colour palette proper to the current environment. It considers a proper colour palette when the colour temperature is aligned with current air temperature, i.e. warmer air temperatures ask for warmer colours and vice versa. It consults weather forecast information, for the current location and time, using a weather API. From the resulting colour palette, it chooses one colour. Finally, it defines the visual elements' colour saturation based on the luminosity in the environment. To do that, it reads the amount of direct light incident in a photo-resistor sensor placed on the top of the installation (see figure 4) After, it maps the value collected in a saturation value. This way, it sets the colour of each visual element in the HSB colour model. Accordingly, the hue is related to air temperature, saturation is determined by the environment's luminosity and brightness is always the same.

Following, the system determines which geometric transformations it will perform in the generated visual elements. It can perform multiple, or none, geometric transformations (i.e. rotation, scale, or both) in each visual element. This way, it decides if it will perform a geometric transformation and what will be the value of this transformation. The maximum and minimum transformations' boundaries were predefined through empirical exploration. Currently, visual elements can be fully rotated and scaled in a third of its original size to three times the same size.

To place a visual element in the composition, the system determines the coordinates where this visual element (the centre-point) will be placed and defines this visual element's lifespan. The initial lifespan is the same for each visual element and decreases every time each visual element stays in the composition. This initial value was defined through empirical explorations. However, the lifespan can be increased with a reward (see subsection 3.2).

The system defines the visual elements' feature in a random fashion (i.e. it chooses one configuration between all the viable options) or based on the system's knowledge (i.e. it chooses the configuration based on its previous experience). The only exception is colour saturation. Subsection 3.3 presents a more comprehensive description of how the system uses its previous experience to influence the generation of new visual elements.

3.2 Outputs Fitness Assessment and Reward

As briefly mentioned, each visual element has a lifespan time that decreases every time that it remains in composition. However, they can be rewarded. A reward increases the lifespan of the visual element. The visual elements are rewarded according to people's interaction with the installation. Data related to people's interaction are collected, from the environment, through CV techniques. In this sense, it looks to the environmental captures for answer three questions: (i) "How many people are near the installation?"; (ii) "How closer are the passers-by from installation?"; and (iii) "How many people are looking at the installation and how are they looking at it?".

For each person's body detected in the environmental captures, the system calculates the distance between the camera and the person and sees if the person is looking at the installation. To detect if the person is looking to installation, it checks if it can detect the person's face in the recognised body. When it detects a face, it checks if it can recognise any eyes. If it detects two eyes, the system assumes this person is more attentive than a person that only one eye is detected. If it does not recognise any eyes, it considers that the person is not attentive to installation and it is only a passer-by. The system understands, this way, how many people are near the installation, the distance between these people and it and the attention each person gives to posters generated by it. Based on these data, the system rewards the visual elements in the composition. It considers that the closer and more attentive the people captured are for the installation, the higher is the reward given to the visual elements in the composition. The rewards values are parameters and might be defined as appropriate. We defined these values thought empirical exploration. To computationally see the people and their body parts, we used the standard OpenCV library.

To provide learning capability to the system, in the first place, we needed permit the system, the ability to evaluate the outputs that it generates. In this sense, the system evaluates the fitness of generated outputs summing the current visual elements' lifespan. Accordingly, the outputs' fitness is directly influenced by environmental conditions. Nevertheless, we did some adjustments to ensure that the outputs with too many visual elements are not favoured in this method. This way, we defined a maximum number of visual elements which can be taken into consideration in this evaluation process. When the output has more visual elements than the maximum amount supported, it calculates the fitness by multiplying the average lifespan of all visual elements in composition by this maximum supported. We defined this value at six by empirical exploration.

3.3 Visual Elements Placement

Initially, the installation begins generating compositions only with the template parts designed. Thereafter the system periodically decides if it should append a new visual element in the composition. This decision is executed by the system in a random fashion.

Visual elements are generated through two methods: (i) *Random Generation* and (ii) *Generation Based on Experience*. To decide which method to use, the system analyses the average fitness of the previously generated outputs, under similar conditions, and assigns a probability for each method. Therefore, if it not designed successful outputs, at the past, in similar conditions, is more probable it continues seeking new grounds, through the employment of *Random Generation* method. On the other hand, if it often designed successful outputs, under similar environmental conditions, it is more probable it employs *Generation Based on Experience method*. In this scenario, the system considers successful an output that has had a proper fitness assessment (see subsection 3.2) under environmental conditions similar to the current ones.

The Random Generation method generates a new visual element in a random fashion. The only exception is its colour. The hue is randomly chosen from a colour palette defined according to air temperature and the saturation is defined according to the environment luminosity (see subsection 3.1). In the end, the visual element is appended to the current composition in a random place.

In contrast, *Generation Based on Experience* method generates a new visual element inspired on the previous generated visual elements. Therefore, it generates new visual elements based on its previous experience. The visual elements are chosen, by the system, often had good fitness assignment when they were created.

To choose the previous output whence it will pick up a visual element, it ranks the outputs based on their fitness. Previous outputs designed under similar conditions receive a fitness reward. This way, it does not only appreciate if a composition was good, but it also verifies if the same composition was good under similar environmental conditions.

The system only bonuses outputs generated when the environments are considered similar. It considers an environment similar when the difference between the environmental readings is within a specific range. These readings include: the number of passers-by; the number of people that were attentive to the installation and how much they were attentive; the environmental level of light; the air temperature; and the time. The smaller the difference between the previous environmental reads and current reads is, the greater is the fitness reward given to the outputs previously generated under this environment. If the difference in one read goes beyond range, the system does not give any reward. The range and the reward amounts are predefined and adjusted when required.

After, the system creates a ranked list where previous designs are sorted by their fitness (with the environmental rewards added). The list is, then, truncated to a predefined length and a probability of selection for each element it establishes. It defines the probability of selection according to the differences between the list's elements fitness. In this sense, the outputs with good fitness — even if they are not in the top of the list — have always more probability of being selected instead of bad evaluated designs.

From here on, the system chooses one output in the list and one visual element in this output. The visual element is, then, placed in the composition with almost the same visual style and in the same position than before. As in the *Random generation* method, the only exception is the colour. We create a method to prevent the same visual element to be placed in the composition multiple time. This way, if the system chooses a visual element that is already drawn in composition, it is forced to choose another visual element until choosing one that is not already drawn.

This way, if specific output achieved good fitness evaluation under the same environmental conditions, the system will often choose their visual elements to place in compositions. By contrast, if the system does not generate good outputs under a specific environmental condition, it will continue exploring and seeking visual elements that obtain good environmental feedback. Thereby, the system learns how to design to the place where it is settled understanding that the dynamics of its surrounding.

Figure 5: Installation placed at store windows, in CHC, over the four weeks of experimental setup stage. From top left to bottom right: (i) installation placed at Rua dos Esteireiros; (ii) installation placed at Praça do Comércio; (iii) installation placed at Rua Adelino Veiga; and, finally, (iv) installation placed at Largo do Poço.

4 EXPERIMENTAL SETUP

To understand the behaviour of the system, we set up the installation in the streets of CHC. Although with a small area, this neighbourhood is composed of streets with multiple typologies and dynamics. This way, it enabled us to experiment with the system in multiple kinds of environmental inputs and people fluxes with few logistical works. Also, it is a historic commercial neighbourhood and, therefore, the posters are constantly demanding passers-by attention.

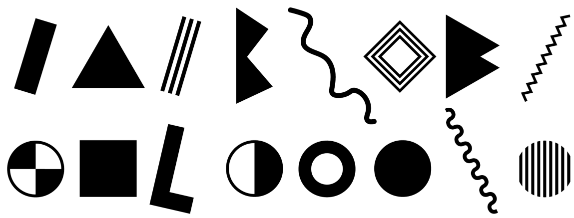

Figure 6: Base shapes designed to be used in the installation experimental setup.

We placed the installation in four store windows. The installation stayed a week in each place. When we moved the installation, we rebooted the system learning module (i.e. we deleted the history entries stored). Accordingly, the outputs generated in each site were only influenced by the data gathered there. Each street where the installation was placed had different environmental characteristics and urban dynamics. The first place was a photo lab in Rua dos Esteireiros, a narrow, dark and few frequented street near the neighbourhood busiest square and restaurant zone. The second place was a historic clothing store in Praça do Comércio, a historic square popular by its historic stores. The third place was a binding workshop/store in a dark and narrow street named Rua Adelino Veiga that connects the historic centre train station and the city hall. Unlike the first place, this is a busy street with multiple shopping places. Finally, the last place was another clothing store in Largo do Poço, a busy square near the city hall. Figure 5 displays the installation in these four places.

We need to define the base shapes and colour palette for this experimental setup. This way, we designed a set of vector shapes (see figure 6) and defined a colour comprehensive colour palette with eleven colours (see figure 7).

The installation did not save data related to the identity of people that it was recognised and, as we see after, sometimes the system recognised false persons in the environment. Nevertheless, it was recorded the interaction of 12722 passers-by during these four weeks (an average of 490 people by day and 3430.5 by week). The busiest place was Largo do Poço with 3970 people by week, followed by Rua Adelino Veiga (3512 people per week), Praça do Comércio (3306 people per week) and Rua dos Estereiros (2934 people per week). The placement of this installation was aligned with the event *Caminhos:* 21st Cultural Week of the University of Coimbra.

The experimental setup unveiled that the system is already able to create poster designs from scratch. Figures 1 and 8–11 displays some of the outputs generated. Also, it was possible to see the environmental conditions surrounding the installation over time, by looking to the outputs. Analysing the outputs, we perceive, for instance, if they were generated when the air temperature is warmer (see figure 10), if they were generated during the night or the day (see figure 9) and/or if it existed many or few passers-by in the street (see figure 8). Figure 11 displays how the outputs were generated by the system, presenting a continuous series of generations. Further information about the outputs could be found at www.cdv.dei.uc.pt/designing-posters-with-for-the-street.

Besides that, the experimental setup enabled us to identify some issues that we did not expect. First, we had some problems with the stores' electrical conditions. Most of them are established in old buildings wherein the electric installations are inadequate. We detected irregular electric voltages that, consequently, reflected themselves in the processing power of our single-board computer. Also, we detected false positives in captures (i.e. the system detected something, e.g. a face, that is not really what it detects). This rarely occurred when we tested the system in a controlled environment (such as an indoor space). However, in the urban environment, it might erroneously reward visual compositions based on false positives detected. As it did not save the captured images (to ensure the privacy of people in public space), we cannot qualify how much the false positives influenced the outputs. Nevertheless, we found some false positives in walls or parked cars, during the routine maintenance.

5 TESTING

We decided to conduct testing sessions in order to assess the installation's behaviour and the outputs that it generates. Each session was split into three stages, each one aimed to evaluate one different aspect of outputs generated. The first stage was focused on evaluating if the outputs communicate the environmental conditions of its surroundings in its design (S1). The second stage was focused on understanding if the system learning capabilities were perceived in outputs (S2). Finally, the third stage was focused on an overall evaluation of the installation and its outputs (S3).

The testing sessions began with an introduction to the installation and its context. Nevertheless, we did not unveil how the environmental conditions were translated into visual information. Afterwards, each user replied a multiple-choice form, divided into three sections (each one corresponding to an evaluation stage). In each question, the users selected the option that better expressed the characteristic(s) mentioned in the question.

We have conducted testing sessions with 35 users. The age group of the users was between 20 and 34 years old, which gives an average of 25.8 years old. From these users, 23 users where males (65,7%) and 12 were females (34.3%). Since we were assessing poster designs, we needed users that understood the particular characteristics of these visual compositions. This way, the testing target group were graphic designers. In this sense, 80% of users (28 users), that participate in testing sessions, work/study in a field related to GD.

5.1 Evaluation of the Communication of the Environmental Conditions (S1)

In this first stage, we were focused on understanding if the generated outputs communicate the environmental conditions surrounding the installation. In these testing sessions stage, each user chose an output that, in our opinion, expressed better the characteristic(s) mentioned in the question. In each question, there was only a correct answer. This answer was assigned, by looking at the data, saved by installation, and selecting the output that represents better the characteristic evaluated in the question (i.e. displays the highest value in saved data).

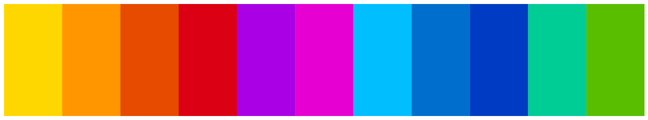

Figure 7: Base colour palette used by the installation at the experimental setup.

Figure 8: Outputs generated, in the same place (Rua dos Esteireiros) with different amount of passers-by near the installation. Left: output generated when the installation captures three passers-by (14/03/2019 at 12:03); Right: output generated when the installation captures twenty passers-by (15/03/2019 at 19:50)

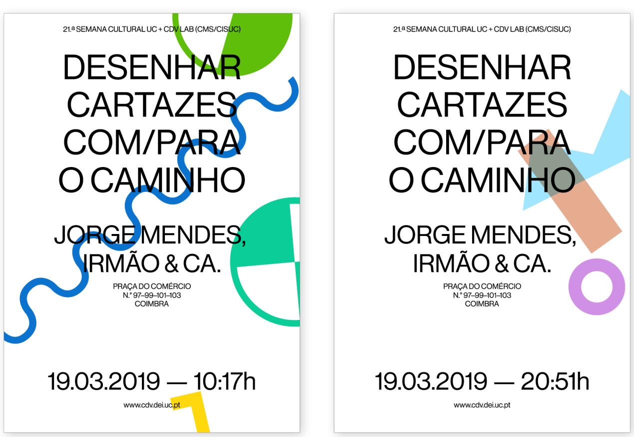

Figure 9: Outputs generated at different times on the same day (19/03/2019) and place (Praça do Comércio). It is observable that, at night, the air temperature is lower (i.e. it uses colder colours) and the light in the environment is lower (it uses colours less saturated). Left: output generated at day (10:17); Right: output generated at night (20:51).

Figure 10: Outputs generated in periods with different air temperatures on the same day (12/03/201) and place (Rua dos Esteireiros). Left: output generated when temperature is 10º Celsius. Right: output generated when temperature is 14º Celsius.

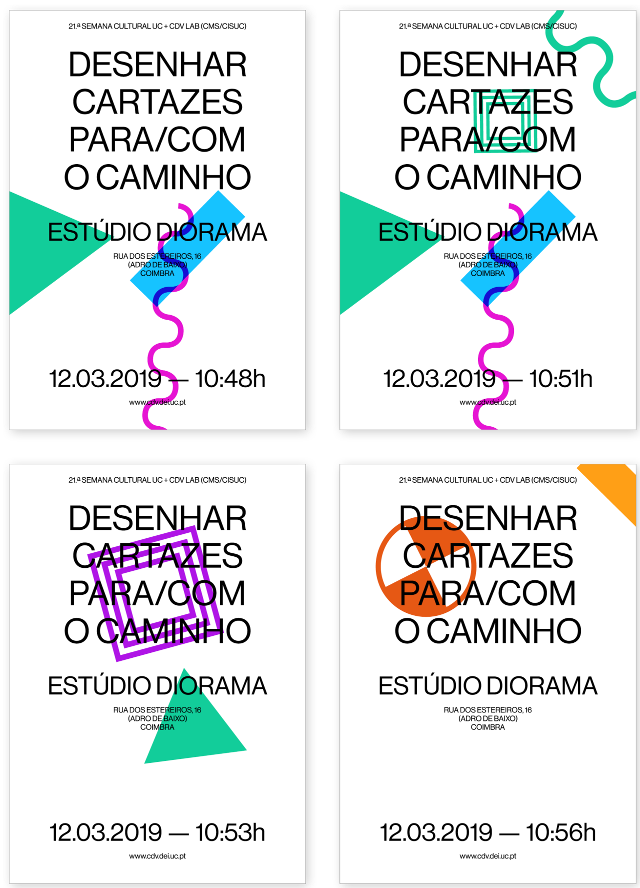

Figure 11: Outputs generated by the system, every three minutes, between 10:48 and 10:56 of 12/03 at (Rua dos Esteireiros).

We asked users seven questions: (S1.1) "What is the generated composition when more people were in front of the installation?"; (S1.2) "What is the compositions sequence generated when existed a more constant flow of people?"; (S1.3) "What is the compositions sequence generated when exists a greater flow of passers-by?"; (S1.4) "What is the generated composition when the air temperature is warmer?"; (S1.5) "What is the generated composition when the sensor caught more direct light in the environment?"; (S1.6) "What is the composition generated during the night?"; and (S1.7) "What is the composition generated during the day?". To users do not infer what was the correct answer based on the poster's content, we only display to them the visual elements' layer. Table 1 unveils the results of S1 testing stage.

Overall, most of the users easily recognised how the environmental conditions, in installation surroundings, affected the generated outputs. In most of the questions (four out of seven), more than 75% of the users identified the correct answer: 85.7% (30 users) identified what was the poster generated with more people in front of the installation (S1.1); 91.4% (32 users) identified the poster generated when the air temperature was warmer (S1.4); 85.7% (30 users) identified what was design generated during the night (S1.6); and 77,2% (27 users) identified what was design generated during the day (S1.7).

Table 1: Results of S1 testing session. In each question (Q), the users (u), had four possibilities of answering: a design that represents the correct answer (C); two designs that were wrong answers (W); and an option that asserted that all designs represent the feature in the same manner (n.d.).

S1	C	W	n.d.
1	85.7% (30 u)	11.4% (4 u)	2.9% (1 u)
2	51.4% (18 u)	42.9% (15 u)	5.7% (2 u)
3	54.3% (19 u)	40% (14 u)	5.7% (2 u)
4	91.4% (32 u)	0% (0 u)	8.6% (3 u)
5	31.4% (11 u)	65.7% (23 u)	2.9% (1 u)
6	85.7% (30 u)	5.7% (2 u)	8.6% (3 u)
7	77.2% (27 u)	8.6% (3 u)	14.3% (5 u)

The only environmental characteristic that could not be retrieved in output, by most of the users, was the amount of light that installation directly caught from the environment (S1.5). In this question, 65.7% of the users (23 users) chose one of the wrong answers. The system changes the saturation of visual elements colours based on the luminosity in the environment (see section 3). As the posters' background is white, when the system caught low light, the visual elements became lighter and easily dissolved themselves in the background. We believe that this confused the users. We consider resolving it by mapping the light, caught in the environment, in the colours' brightness instead of the colours' saturation.

Also, users had difficulty in correctly answering two more questions. Only 51.4% (18 users) correctly chose the posters sequence when the flow of people is greater, i.e. when existed more passers-by near the installation (S1.2). Furthermore, only 54.3% (19 users) correctly chose the poster sequence when the flow of people is more constant, i.e. when passers-by were captured in more regular intervals (S1.3). This way, we consider necessary to continue working in order to understand how to communicate better these characteristics.

5.2 Evaluation of System Learning (S2)

In the second testing stage (S2), we were focused on perceiving if the system learning capabilities are noticed in the generated outputs. First, we needed to measure the error of similarity between outputs, according to data saved by the system (i.e. the similarity between outputs according to system point of view). The error of similarity allows understanding how system learn capabilities are employed on outputs, i.e. if two outputs were generated in a similar environment, both should be similar visually. This way, if two outputs are visual similarly and generated in a similar environment, the system already learned how to design for the surrounding where it is located. On the other hand, if two outputs are visually distinct but generated in a similar environment, it has not yet learned how to design for these surroundings. During the testing session, we invited the users to perform the same task (i.e. to measure the similarity between outputs according to his/her point of view). In the end, we compared the results between the two classifications. The error of similarity between the outputs was measured on a range between 1 and 5, wherein 1 means that the posters are not similar and 5 that the outputs are highly similar or, even, equals.

The error of similarity, between two outputs, has computed in two dimensions: environmental; and visual. The environmental similarity between two outputs is the computed difference between the environments, that both were generated, in terms of: (i) people interacting with the installation (i.e. number of passers-by, their distance to installation and percentage of people looking directly to the installation); (ii) air temperature; and (iii) light caught. On the other hand, the visual similarity between two outputs is the computed difference between the visual elements' features that compose both outputs. To do that, we compute the differences between in terms of: (i) amount of visual elements; (ii) fitness; (iii) colour average of visual elements; and (iv) number of visual elements with the same shape. Each component has the same weight in the final measure. If this difference is greater than a threshold, we consider that the posters are distinct (i.e. the difference is 1). Column C in table 2 unveils the average computed error of similarity between in sequences tested in S2 testing.

We tested sequences of outputs generated within different time intervals and with distinct environments surroundings. The users defined the similarity of five sequences: (S2.1) a sequence composed by outputs generated in the same day and place only in the afternoon (13:00 – 19:00); (S2.2) a sequence composed by outputs generated in the same day and place during all day (9:00 – 19:00); (S2.3) a sequence composed by outputs generated at the same hour (13:00) and place, over consecutive days; (S2.4) a sequence composed by outputs generated at the same hour (09:00) and place, over consecutive days; and (S2.5) a sequence composed by outputs generated at the same hour (23:00) and place, over consecutive days. The outputs were displayed to users in chronological order. Like in S1, we only displayed to users the outputs' visual elements. This way, the users did not see the information related to time/date presented in the template parts. Table 2 unveils the results of S2 testing stage.

Table 2: Results of S2 testing session (S2.1 – S2.5) and the computed error of similarity between the outputs in tested sequences (C). In these questions, the users (u) answered in a range between 1 and 5, where 1 represents that the posters are not similar and 5 that they are highly similar.

S2	1	2	3	4	5	C
1	5.7% (2 u)	2.9% (1 u)	14.3% (5 u)	48.6% (17 u)	28.6% (10 u)	3.9
2	0% (0 u)	2.9% (1 u)	31.4% (11 u)	48.6% (17 u)	17.1% (6 u)	4
3	20% (7 u)	35.7% (9 u)	22.9% (8 u)	20% (7 u)	11.4% (4 u)	4.5
4	22.9% (8 u)	14.3% (5 u)	31.4% (11 u)	25.7% (9 u)	5.7% (2 u)	4.4
5	25.7% (9 u)	22.9% (8 u)	31.4% (11 u)	17.1% (6 u)	2.9% (1 u)	4.4

Because the outputs in tested sequences were generated at equally spaced time intervals, the error of similarity computed in between them is similar. Indeed, the less similar the sequences were S2.1 and S2.2 because there were composed of outputs generated in different hours during a day. Although similarity is an abstract concept and, consequently, each user has his/her own definition, in the first questions (S2.1) and (S2.2) almost half (48.6%) of users (17 users) chose the rounded value of C. Moreover, we observed that in all questions the majority of users' answers were distributed between the rounded value of C and the values of its immediate surrounding. However, we do not retrieve conclusive data to draw definite conclusions of this testing stage. Although the system learning capability was slightly visible along the time, it is a feature that should be further improved and studied.

5.3 Overall Evaluation (S3)

Finally, in the last stage (S3), we were focused on measuring the visual quality of the generated outputs and the relevance of this project. This way, we asked users the following questions: (S3.1) "How much he/she considers the project interesting?"; and (S2.2) "How much he/she likes the posters compositions?". Like in S2, the users answered in an integer scale of 1 to 5. In the end, we invited the users to give feedback/comments related to the project (S3.3).

In the first question, (S3.1), 74.3% of the users (26 users) considered the project extremely interesting giving it the maximum value in range (5). In relation to the visual quality of the outputs generated (S3.2), all users consider that the visual quality is at least satisfactory (3). This way, 51.4% (18 users) of the users considers that the quality of the outputs is good (4) and 31.4% (11 users) considers the outputs exceptionally good (5). Table 3 unveils these results.

Comments made by the users (S3.3) were valuable for pointing future directions towards the improvement of the system. Only five users (14.28%) gave their comments/feedback and most of the answers touched on the inclusion of more environmental data in designs generated. We highlight the following comments: (i) the system could enable the environmental conditions to also influence the render of template parts; (ii) the system could develop/employ a method to orderly place the visual elements in the composition (e.g. using a grid or avoiding overlaps); (iii) visual elements could represent the direction where most passers-by go; and (iv) visual elements shapes could be more complex.

Table 3: Results of S3.1 and S3.2 questions in S3 testing session. In these two questions, the users (u) answered in a range between 1 and 5, where 1 represents interesting/dislike and 5 very interesting/good.

S3	1	2	3	4	5
1	0% (0 u)	0% (0 u)	2.9% (1 u)	22.9% (8 u)	74.3% (26 u)
2	0% (0 u)	0% (0 u)	17.1% (6 u)	51.4% (18 u)	31.4% (11 u)

6 CONCLUSIONS AND FUTURE WORK

In this paper, we comprehensively described the development process behind an interactive installation that generated poster designs based on the environment where it is located. It designs outputs employing a generative design system that is capable of translating data (gathered in the installation's physical surroundings) in poster designs. The installation's outputs demonstrate an approach where graphic designers take advantage of the new design processes, enabled by the technological advances of the last years, in the poster design scenario. Also, these outputs integrate themselves in a more seamless way, comparing with traditional approaches, in the surrounding environment.

The generated posters are composed of two kinds of structural elements: (i) template parts; and (ii) visual elements. Template parts are changeless. Alternatively, visual elements are placed dynamically by the system and change according to the data gathered from the installation surroundings. Each visual element is placed in the composition with a set of visual features associated (i.e. position, lifespan, shape, colour, scale, and rotation). To define some of these features C-AD are used. The lifespan of a visual element decreases every time that it is in composition unless it is rewarded. The rewards are calculated based on the people's interaction and behaviour in the physical surrounding near the installation. To capture this, we used of CV techniques. Also, the system is able to learn how to design posters based its previous designs and, in the feedback that it collected from the environment.

We experimentally setup the installation at four store windows of different streets in CHC over four weeks (a week per store). After, we conducted testing sessions to assess the outputs generated and the installation behaviour over these four weeks. The testing sessions unveiled that most of the users recognised the environmental conditions in outputs generated. However, we cannot draw final conclusions about the system learning capability and the way that the people perceive this capacity. Also, users considered that the outputs have visual quality and the project extremely interesting.

Future work will focus on improving the way the system transmits the environmental conditions that users do not recognise easily (i.e. light caught from the environment, people's frequency, and people's flux). Also, we will improve the system learning module to it be easily perceived by people. Furthermore, we have the intent to develop a new module that will enable the system extracts shapes from environmental captures and to increase the amount of data gathered in physical surroundings near the installation.

ACKNOWLEDGEMENTS

The installation hardware was partially funded by *Caminhos: 21st Cultural Week of University of Coimbra* (2018). The first author, Sérgio Rebelo, is funded by Fundação para a Ciência e Tecnologia (FCT), Portugal, under the grant SFRH/BD/132728/2017. We would also like to express our gratitude to the store owners that permit we placed the installation in their stores (Estúdio e Laboratorio Diorama, Jorge Mendes, Irmão & C.ª, Lda., Chronos' Paper, and ELLAYNE). Also, we express our gratitude to the users that participate in testing sessions.

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