Evolutionary Experiments in Typesetting of Letterpress-Inspired Posters

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Abstract

In this paper, we present a system that generates letterpress-inspired typographic posters from a user-given text. This system employs lexicon-based approaches not only to recognise emotions and sentiments but also the colours related to the content. Moreover, the system generates and evolves outputs employing an Evolutionary Computation approach. The generated outputs are evaluated according to their legibility, aesthetics and semantics, throughout a multi-criteria hardwired fitness function scheme. Also, this system enables its users to guide the generation process through the dynamic definition of several setting parameters.

Introduction

Visual artefacts for public proclamation, *i.e.* posters, were already present in ancient societies and, over the centuries, they adapted themselves to the new social and technological contexts. Nowadays, they still maintain a palpable presence in our cities' landscapes (Guffey, 2014). The recent advances in computational tools, especially on Artificial Intelligence (AI), are promoting deep social changes and, consequently, graphic designers began to design posters exploring these innovative technologies in order to create more interactive and immersive artefacts.

In this paper, we present a work in progress system that generates letterpress-inspired typographic posters from a text inputted by the user. Letterpress is a printing technique that became popular on the follow-up of the industrial revolution because it allowed a cheaper, easier and faster printing of commercial posters for mass communication (Guffey, 2014; Meggs and Purvis, 2016). Nevertheless, the design of these posters was slightly different from the typical contemporary design process. At the time, letterpress designers created posters while trying to fill a matrix, often in collaboration with the client. The design decisions were very pragmatic: extensive sentences were composed in condensed typefaces, and short sentences were composed in extended typefaces. Also, the content's most important parts were emphasised through the use of bigger typefaces (Meggs and Purvis, 2016).

The present system generates outputs using a workflow, similar to the letterpress design process, based on our previous work (Rebelo et al., 2018). Briefly, the system (*i.e.* the designer) composes the content, inputted by the user (*i.e.* the client), dividing it into text boxes in order to fulfil, as much as possible, the posters' canvas (*i.e.* the matrix). In this process, lexicon-based approaches are employed on the content to recognise sentiments, emotions, and colours related to the text. Also, an Evolutionary Computation (EC) approach is employed to create and evolve a population of poster designs. The generated posters are evaluated according to its (I) legibility, (II) aesthetics, and (III) semantics. The fitness of each output is assigned by a multi-criteria hardwired fitness function scheme. Also, like in the traditional letterpress process, the users may guide the generative process. Thus, the users may communicate their preferences to the system by defining, and iteratively updating, several setting parameters in a dedicated interface. This system is available online at https://pf.dei.uc.pt/eetlp.

System Overview

The system is a web application that generates posters through the employment of 3 main modules: (I) Input Processing; (II) Evolution; and (III) Evaluation. The Input Processing module employs lexicon-based approaches to recognise sentiments, emotions and colours related to the text. The Evolution module randomly initialises a new population of candidate solutions (*i.e.* poster designs) and uses a Genetic Algorithm (GA) to evolve this population. The Evaluation module assigns the fitness of each poster through a multi-criteria hardwired fitness assignment scheme. The fitness is calculated based on 3 criteria: (I) legibility; (II) aesthetics; and (III) semantics. A schematic of the system is overviewed in Figure 1.

Through a dedicated interface, the users can guide the system's generative process by defining several settings parameters. The parameters are (I) the weights of each criterion in the fitness assignment scheme, (II) the GA's setup parameters (*i.e.* the number of generations, the population and elite sizes, and the mutation probability), (III) the visual proprieties of the outputs (*i.e.* the posters dimensions, the number of rows in the grid, the sizes of the margins, the visual centre offset, and the optimal percentage of white space), (IV) the available colours, and (V) the typeface and its available weights. These parameters may be modified at any time during the generation. This way, during the generation, users can guide the system, adjusting these parameters.

Also, users may export the outputs at any time during the evolution.

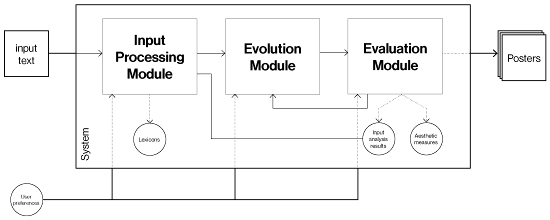

Figure 1: Schematic of the system's architecture.

Input Processing Module

The Input Processing module analyses the text, inputted by the user, to recognise the sentiments, emotions and colours related to it. This module is implemented by using the natural language facility library *Natural.js* (Umbel, Ellis, and Mull, 2020) and the lexical database *WordNet* (Fellbaum, 1998).

First, this module subdivides the text into lines, using a sentence tokenizer. After, it performs a lexicon-based analysis on the words of the text. Thus, after tokenizing and lemmatising the input text, each word is searched in a word-emotion association lexicon developed by Mohammad and Turney (2012). This lexicon enables the recognition of 8 basic and prototypical emotions (*i.e.* anger, anticipation, disgust, fear, joy, sadness and surprise) and 2 sentiments (*i.e.* positive and negative) in about 15000 English words. Thus, it perceives what are the parts of the text with more emotional and sentimental charge.

The present module also performs an analysis to recognise the intensity of the relation between the colours and the text. This analysis is performed using a word-colour association lexicon developed by Mohammad (2011). This lexicon scores the intensity of the relation of 14000 English words with 11 colours: black; blue; brown; green; grey; orange; purple; pink; red; white; and yellow. In the end, the module creates a list that describes the intensity of the relation of each one of the 11 colours with the text. This list is sorted by intensity. The intensity of a colour is the sum of the scores obtained whenever this colour is associated with a word in the text.

Evolution Module

The Evolution module implements a GA to create a population of poster designs at random and, subsequently, evolve them employing variation operators, *i.e.* crossover and mutation, on the most promising outputs. The posters are selected by tournament based on their fitness. This method practices elitism, persevering the best individual of each generation to the next generation.

Each poster is a set of arranged text boxes. The text boxes are encoded as a sequence of arrays of numbers (*i.e.* the genotype). The first array in the sequence is a one-position array that encodes the poster's typography colour (*i.e.* the colour configuration gene). The following arrays encode the text boxes (*i.e.* the text boxes genes). Each text box gene is composed of 3 numbers encoding the font's weight, the text box height, and the font size in percentages of the height, respectively. Since the content of the posters may have different lengths, the number of text boxes and, so, the size of genotype may vary. The posters' canvas is subdivided in a one-column grid with multiple rows that constraint the text boxes position and sizes. Perceptible poster designs (*i.e.* phenotypes) are generated through the rendering of the text boxes, according to the settings encoded in genotype.

Initialisation The initialisation method generates a population of poster designs at random. Thus, for each individual in the population, it defines the colour configuration gene by randomly assigning one colour from the range of options available. The number of text boxes is defined by the number of lines of the text (*i.e.* each text box contains a line). The proprieties of each box are defined as follows. The font's weight is randomly selected according to the range of options available for the selected typeface. The height of the text boxes, although selected at random, is defined by ensuring that the text boxes fill all the available space on the canvas. We ensured this by randomly generating a sequence of numbers with the same length of the number of text lines and the sum equal to the number of rows of the grid. Next, this sequence is shuffled and each number is assigned to a text box. The font size is always defined at 100% of the height.

Variation Operators Poster designs are evolved iteratively, through the employment of crossover and mutation operators. Both operators are designed to preserve the validity of the generated individuals.

The crossover operator generates new poster designs through the exchange of genes between two parents. This way, it randomly selects two parents regarding their fitness and, thereafter, employs a uniform crossover method, which randomly selects which of the parent will give the gene to the children. This operator does not crossover the genes related to the height of the text boxes, ensuring that the generated children fulfil all the available space on the canvas.

The mutator operators perform random modifications in some parts of the individuals' genotype. We designed these operators by ensuring that they covered all the search space. This resulted in 2 operators: *Independent*; and *Swap*. The mutations are performed based on a certain probability. Thus, the system for each candidate solution in the new offspring randomly defines if it will be mutated and, next, selects the mutation operator. Each operator has the same probability of being selected. The *Independent mutation* operator randomly selects a gene and, subsequently, randomly selects a parameter in the gene for the mutation. Each type of parameter has its own mutation method. If the colour configuration gene or the font's weight parameter of a text box are selected, it randomly assigns a value to it according to the options available (*i.e.* number of available colours or weights). If the text box's height parameter is selected, two genes are randomly selected, having one, at least, the height value bigger than one. After, it decides what will be the gene that will decrease the height and the one that will increase. This selection is performed randomly unless one of the selected genes have the value 1. In this case, the gene with the value 1 will increase its height and the other will decrease. Finally, when the font size parameter is selected, it decreases or increases this value in 1%. The direction of this mutation is randomly calculated unless the value is already in its maximum threshold, *i.e.* 100% (the value will only be decreased) or in its minimum threshold, *i.e.* 30% (the value will only be increased). On the other hand, the *Swap mutation* operator, as the name indicates, randomly selects two text boxes, in the same individual, and swaps the value of their genes.

Evaluation Module

The Evaluation module implements a multi-criteria hard-wired fitness assignment scheme to evaluate the outputs. This way, the outputs are assessed according to 3 criteria: (I) legibility, *i.e.* how much content it is possible to read on the poster; (II) aesthetics, *i.e.* how much the design of poster satisfies a set of aesthetics measures; and (III) semantics, *i.e.* how much the poster visual characteristics convey the semantic meaning of its content. Each criterion has its evaluation method. The fitness of each poster is calculated by the weighted arithmetic mean of the legibility, aesthetics and semantics. The weight of each criterion is defined by the user.

Legibility The legibility objective measures how much of the content is legible on the poster. The legibility of each text box is the difference between its target width (*i.e.* the posters available width) and the width of its content when rendered. A text box's content should always be rendered inside of the text box (*i.e.* target width) and the white space, inside of the text box space, should be minimised as much as possible. This way, the legibility of a text box is the difference between the target width and the width of content when rendered. This difference is after being mapped to assign a poor assessment when the rendered text exceeds the size of the poster and to prejudice the text boxes that surpass a certain amount of white space. The overall legibility value of a poster is the weighted arithmetic mean of the value of text boxes. The weight of each text box in the mean is defined based on its height.

Aesthetics The aesthetics objective measures how much the design of the poster satisfies a set of aesthetic measures for the design of typographic posters. These measures are based on the work of Harrington et al. (2004). Nevertheless, they were adapted to the context of this work. This way, the aesthetics of a poster is evaluated according to (I) the alignment, (II) the regularity, (III) the balance, (IV) the white-space fraction, and (V) the composition security. The overall aesthetic measure is the arithmetic mean of these attributes.

The alignment attribute measures how regular is the horizontal placement of the text boxes on a poster. Thus, the module compares the distance between the values of the vertical positions of the left edges of the neighbouring text boxes. The closer the vertical distance between text boxes, the higher is the alignment score. The overall alignment measure is the arithmetic mean of all distances.

The regularity attribute measures how regular is the vertical placement of the text boxes on a poster. The calculation of the regularity is similar to the calculation of the alignment. However, it compares the positions of the top edges instead of the left edges.

The balance attribute measures how much the poster is centrally balanced. The centre balance of a poster is the difference between the centre of its visual weight and its visual centre. The centre of the visual weight of a poster is calculated based on the visual weight of its text boxes. The visual weight of a text box is defined by its area times its optical density. After calculating the visual weight of all text boxes, the overall measure of balance is calculated according to the method purposed by Harrington et al. (2004).

The white space fraction attribute measures if the percentage of white space in the poster is according to a certain optimal percentage threshold. This way, the overall measure is the absolute value of the difference between the current percentage of white space and the optimal percentage.

The composition security attribute measures if the text boxes positioned near the edges of the poster are secure and do not appear to fall off. The security of each text box is the minimum between the top and bottom edges. The overall value is the minimum between the values of all the text boxes.

Semantics The semantics objective measures how much of the posters' visual characteristics convey the semantic meaning of its content. This way, the most important parts of the content should be emphasised in the layout, over the less important ones, and the typography colour should be related to the content. The semantics of a poster is, then, evaluated according to (I) the typography colour, and (II) the layout of the text boxes. The overall semantic measure is the arithmetic mean of these attributes.

The colour employed on the typography conveys the semantic meaning of the poster's content when it is the colour most related to the content, according to the results of the analysis performed by the Input Processing module. This way, the overall value of the appropriateness of a typographic colour is the distance between the current used typographic colour and the most related colour to the content. This distance is calculated based on the content-colour intensity list defined before. When the most related colour is not available, the module considers that the most related colour is the available colour following on this sorted list.

The layout of the text boxes should emphasise the most important parts of the content by assigning them higher text boxes. We consider that the most important text boxes are those with a higher amount of emotion and sentiments recognised in the analysis performed by the Input Processing module. This way, the module defines the weight of one emotion on the poster by dividing the total number of emotions and sentiment recognised by the number of rows of the grid. After, it defines the optimal height for each one of the text boxes on the poster by multiplying the number of recognised emotions, in each text box, by the emotional weight calculated before. The appropriateness of a text box's layout is, then, the distance between its current height and its

Figure 2: Typical outputs generated by the system. More outputs can be visualised at https://cdv.dei.uc.pt/evoposter/

optimal height. The overall value of the appropriateness of a layout is the arithmetic mean of all distances.

Discussion and Conclusions

We conducted a set of preliminary experiments to study and analyse the possibilities of the system evolving posters for several contents with several lengths and textual purposes. The experimental parameters used in these experiments were defined by empirical exploration and summarised in table 1. The weights of the criteria in the fitness assignment scheme were 90% for legibility, 5% for aesthetics and 5% for semantics. These weights were also defined by empirical exploration. The experiments were conducted using 3 typographic families published by Font Bureau and available at *Adobe Typekit* service: (I) *Bureau Grot*; (II) *Titling Gothic FB*; and (III) *Benton Modern Display*. In these experiments, the system used all the available colours and typefaces weights.

Table 1: Experimental parameters.

Parameter	Value
Generations	300
Population size	20
Elite size	1
Mutation probability	0.7
Phenotype size	298×420
Margin size	15 px
Grid	26×1
Optimal percent of white space	50 %

Figure 2 display some results. More results are available at https://cdv.dei.uc.pt/evoposter/. Visually observing the results, one can conclude that the system can generate posters that achieve a high level of diversity and variation in terms of layout and colours. We also observed that the system, for the same text and under the same settings, generates results that although share similar visual characteristics are not identical. However, the diversity of the results is directly related to the distribution of emotions on the text and/or the strength of the relation of some words with colour. Texts with a uniform or weak emotional and sentimental charge and/or weak relation with colours tend to generate more diverse outputs.

Besides its capability to generate posters from scratch, we also observed that the system is a functional co-creativity tool. We believe that this system is a useful tool for enhancing users creativity (mostly graphic designers) when they design posters, especially in the earlier and most exploratory stages of their design processes. Also, it reveals the potential that AI techniques may have in the future practice of GD, mainly EC. Future work on this system will focus on (I) exploring different fitness assignment schemes, (II) using Natural Language Understanding methods to create more reliable textual analyses, and (III) including images and illustration on outputs.

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