ORIGINAL ARTICLE

A Method for Evaluating Food Image Complexity from the Photographer's Perspective

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Abstract: How complex should the food photographs of a restaurant menu be? Studies on image complexity have been conducted using objective and subjective approaches. Nevertheless, neither approach considers the factors that photographers commonly manipulate during image creation. Therefore, this paper proposes a methodology to evaluate the impression of complexity considering these factors. Through interviews, factors like the Camera Angle, Background, Lighting, Light Color, and the Number of Decorative Elements were identified and defined. Based on these definitions, food images were analyzed and tested by participants who assessed their impression of complexity. The results suggested that the amount of decorative element is a factor with a significant effect on the impression of complexity. Furthermore, the correlation between the number of decorative elements and the evaluations suggested that measuring food image complexity according to the decoration in the image is a closer representation of the impression of complexity judged by human subjects.

Keywords: Food image complexity, Food photography, Visual perception

1. INTRODUCTION

In the restaurant industry, menus often feature carefully prepared images of the food as a form of the food's description or advertisement. The way the images are created often corresponds to the type of message the restaurants want to transmit. However, how simple or complex do these images have to be, is still a topic of discussion between all those involved in their creation.

The creation process usually involves several protagonists [1]. The chef/cook, art director/designer, food stylist, photographer, among others. Although each protagonist has a specific role during this process, the photographer and the food stylist actively engage with the food, manipulating factors like the camera angle, background, lighting, and decorative elements (edible or non-edible), resulting in changes in the visual aspects of the final image. Hence, achieving the desired image.

In recent years, several studies have experimented on the subjective perception of visual complexity. However, this study could not find dedicated studies where the approach for measuring image complexity is taken from the commonly manipulated factors when creating the image. Therefore, this study aims to investigate the subjective perception of visual complexity by proposing a method to estimate the complexity of an image using the photographer's perspective (creation process perspective) and contrasting the proposal with other image complexity

methods used on subjective evaluations. This approach was considered vital since it would create a new discussion on how these creation process factors affect the impression of complexity of food images. Thus, creating a baseline for future experimentation on related subjects. Furthermore, the importance of image complexity in food images could be favorable on studies related to the impression of deliciousness since one goal of creating food images is to show the food as delicious as possible to the viewer [1,2].

2. BACKGROUND

2.1 Image Complexity

From the perspective of food photography. The concept of complexity is commonly associated with the effort required to create the image [1,2]. In other words, the type of light, camera angle, background, and decorative elements used during the creation of the image. Furthermore, the amount and position of these "decorative" elements are important, since in most cases, it determines the composition of the final image (see Figure 1).

On the other hand, the definition of image complexity can also be understood from different perspectives depending on the field of study and application domain. Studies on objective measurements of complexity used mathematical models to calculate the length of the shortest computer program, that produces an object as an output. In other words, to measure the computational resources needed to complete a task [3]. Another mathematical

Figure 1: Left: Composition with no decorative elements
Right: Composition with several decorative elements

approach uses the concept of entropy as part of the definition of complexity, which consists of quantifying the amount of information in a variable that can be interpreted as how easy or difficult it is to guess the information [4].

Additionally, other studies relate their definition of image complexity as the amount of detail or intricacy of the objects in the image [5], or the visual aesthetics of the image [6]. Furthermore, image complexity has also been discussed not only by the perception of the spatial properties of the object but also by its temporal dimensions [7, 8].

In contrast, studies on the subjective measurement of visual complexity have been conducted by adopting different objective measurements to observe the correlation through subjective evaluations. For instance, a study on the impression of complexity used image categorization to analyze the criteria in which people define complexity [9], suggesting that visual complexity can be connected to a multi-dimension representation in terms of quantity of objects, clutter, symmetry, organization, and colors.

Other studies proposed methods based on the statistics of contrast and spatial frequencies of the images [10], and prediction models that use regression analysis to map the relationship between the visual characteristics of the image with the complexity perception [11]. Moreover, there is evidence that objective measures such as Shannon's entropy can be used to correlate subjective evaluations. Such is the case of a study that explored the correlation between the entropy of dot pattern images and several verbal expressions, suggesting that the visual complexity is highly related to the length between dots [12]. On the other hand, studies with more practical applications, especially in design, have used curvature entropy and genetic algorithm to describe shape-generation in curve profiling for automobile profile design, suggesting that the curvature entropy can express the characteristics of the shape in a curve profile at a product level [13].

In short, the literature suggests that research on image complexity can be conducted with both objective and subjective evaluations. Moreover, several studies used Shannon's entropy to contrast their proposals. Therefore, this study also considered using Shannon's entropy to contrast the performance of the proposed methodology.

$$\text{Entropy Index} = - \sum_{i=0}^n p_i \log_2 p_i$$

$$p_i = \frac{\text{Number of occurrences of intensity level } i}{\text{Number of Pixels}}$$

Figure 2: Shannon's entropy index

2.2 Shannon's Entropy of Information

Claude Shannon introduced the Entropy of Information theory in 1948, as the average level of "information", "surprise" or "uncertainty" inherent in a variable's possible outcomes [14, 15, 18].

Since then, many interpretations had been made about the entropy value of things and the probability of distribution as a measurement of the order or the amount of information.

Taking Shannon's Entropy theory into the image evaluation, Tsai et al. [15] proposed that this theory can be used for measuring the visual aspects or the amount of information within an image using Shannon's Entropy Index (SEI) (see Figure 2). In other words, the SEI measures the number of occurrences of certain pixel intensity to obtain an index of complexity.

3. OBJECTIVES

The objective of this paper is to propose a methodology to evaluate the impression of complexity of food images considering the factors that photographers commonly manipulated during the creation process of the image.

By using the photographer's approach to image complexity, this proposal could provide an insight over which factor/s of the image creation process affects the impression of complexity.

4. METHODOLOGY

4.1 Factors' Definitions and Measurements

Online and phone interviews with 15 photographers were conducted. The purpose was to identify the factors that are commonly manipulated during the creation of food images. Thus, the interviews assisted in translating empiric knowledge into measurable units for each identified factor. The interviews showed that the most manipulated factors correspond to: "Camera Angle, Background, Lighting, Light Color and the Number of Decorative Elements that surround the food" (see Table 1). The definitions and measurements for each factor were discussed during the interviews and are described as follows.

Table 1: Interview Summary – Which factors does the photographer usually manipulate when creating food images?

Factor	Reported as commonly manipulated factor
Camera Angle	11
Background	13
Lighting	14
Light Color	5
Number of Decorative Elements	15

4.1.1 Camera Angle

This factor was defined as the angle at which the camera is set towards the food. Among the various angles in which a food image can be taken, three significant groups were reported in the interviews. Thus, related literature supports the photographers' reports [1,2]. Therefore, the camera angles were defined as “Low Angle” or camera placed between 0 and 35 degrees to the ground, “Medium Angle” or camera placed between 35 and 65 degrees to the ground, and “High Angle” or camera placed between 60 and 90 degrees to the ground (see Figure 3a).

4.1.2 Background

There is an infinite number of backgrounds that can be used to create food images. However, during the different interviews, photographers established that they could be categorized into two main groups: “solid color-based” background and a “texture-based” background. Although, evidence suggests that the color and type of texture [16] of the background may influence the perception of complexity. The scope of the study was to observe the effect of the background type instead of the effect of the background color, texture pattern, or the combination of both (see Figure 3d).

4.1.3 Lighting

During the interviews, the photographers defined lighting as the number of light sources and light diffusers used when creating the food images. However, most of the photographers remarked that from visual inspection of food images, it is difficult to accurately determine this number. For this reason, this factor was re-defined as the percentage of the image that is composed of the highlight on the food. The highlight on the food is the proportion (pixels) of the image where the water droplets/moisture of the food reflect the light source/s resulting in white pixels. The calculation was made using a photography edition software Adobe Photoshop. During the calculation, white background images and white cutlery were excluded since they do not represent the highlighted areas on the food or the decorative elements. Additionally, different graduations

Figure 3a: Left: Low angle, Center: Medium angle, Right: High angle **Figure 3b:** Left: Solid color-based background Right: Texture-based background **Figure 3c:** Left: Before highlight selection Right: Highlight selection (blue) **Figure 3d:** Left: Image with 0 elements Right: Image with 2 elements

of the highlight were also considered since the highlights are not sharp-edged on any food image. (see Figure 3c).

4.1.4 Light Color

The light color was defined as the white balance used when taking the photograph. The white balance is the color temperature of the light, and it is measured in Kelvin (K). In most digital image formats, the information regarding color temperature can be obtained from the metadata. However, online images are treated and saved under conditions where the files rarely preserve the information regarding the color temperature.

4.1.5 Number of (Surrounding) Elements

This factor was defined as a numerical value representing the clusters of decorative objects that surround the main food (target food) in the image (see Figure 3d). Photographers agreed that decorative elements placed on top or within the food are not part of the decorative objects of the image but the decorative objects of the food. The difference between these two types of decorative objects is that the chef manipulates the decorative objects of the food. In contrast, the photographer or food stylist manipulates the decorative elements that surround the

Table 2: Food categories screening results

		Sushi	Pizza Margherita	Cheeseburger	Steak	Pasta Bolognese	Curry	Fried Chicken
Familiarity	Means	3.80	4.70	5.50	4.90	4.60	4.00	4.50
	S.D.	0.87	0.64	0.50	0.83	0.66	0.45	0.50
Preference	Means	3.40	4.80	5.40	4.70	4.50	3.20	4.40
	S.D.	1.91	0.75	0.49	0.64	0.50	0.40	0.66

Figure 4: Visual stimuli

food. Furthermore, few photographers mentioned that as a sub-factor, the position of these elements might affect the impression of complexity. However, this study aimed to observe the effect of the presence or absence of such elements and not the effect of the positioning of the elements. Therefore, while the supposition could be valid, it was not considered inside the scope of this study.

5. IMAGE ANALYSIS AND EXPERIMENT ON THE IMPRESSION OF COMPLEXITY

An experiment was conducted to test the impression of complexity on food images. The experiment consisted of analyzing different food images and determine the effect of these factors over the impression of complexity. Then, determine whether the evaluations correlate with the proposal and the SEI for comparisons purposes.

5.1 Food Category Selection

Food image evaluation can be easily affected by the preference and familiarity of the person towards the food. A screening process took place with 10 International students from the University of Tsukuba. The purpose was to discard food categories that are not popular in terms of preference and familiarity major differences may affect the impression of complexity [17]. Participants were asked to rate on a scale from 0 to 6 how familiar is the food and how much they like the food. The results of

the screening showed Cheeseburger to be the most familiar food type, followed by Steak, Pizza, Pasta, Fried Chicken, Curry, and Sushi (see Table 2). For the experiment, the 4 categories with the highest scores in both familiarity and preferences considering the standard deviations were selected.

5.2 Visual Stimuli

A total of 32 food images were selected from different free copyright online sources (see Figure 4). For each category, a set of 8 images (A-H) were selected and processed to maintain a constant resolution in terms of pixel amount and image ratio within each category (800×600) for cheeseburger, pasta, and steak; and (800×800) for pizza. The analysis of each image followed the definitions described previously. However, the light color analysis could not be performed since the images did not have the data regarding the white balance. Therefore, this factor was excluded from the image analysis. Leaving it factor pending for future experimentation. The analysis of the 32 images was performed by a different group of photographers and each response was discussed to get a consensus (see Table 3).

On the other hand, the SEI was calculated using an open-source software “Cake Image Analyzer” [18]. This software uses Shannon’s Equation (see Figure 1), to process each pixel of the image according to the histogram information (see Table 3).

Table 3: Image analysis results and SEI

	Image	Camera Angle	Background	Lighting	Number of Decorative Elements	SEI		Image	Camera Angle	Background	Lighting	Number of Decorative Elements	SEI
Pasta	A	Medium	Texture	15.20%	3	4.993	Steak	A	Medium	Texture	16.21%	4	5.122
	B	Low	Solid	18.60%	0	4.788		B	Medium	Solid	18.95%	0	4.793
	C	Low	Texture	10.52%	0	4.953		C	Medium	Texture	4.46%	3	4.707
	D	Low	Texture	20.23%	3	4.875		D	Medium	Texture	15.82%	0	5.025
	E	Medium	Texture	19.36%	4	4.908		E	Medium	Texture	17.37%	3	4.850
	F	Medium	Solid	18.72%	0	4.702		F	Medium	Texture	3.35%	3	4.695
	G	Medium	Texture	16.19%	4	4.806		G	Medium	Texture	3.82%	0	4.813
	H	Medium	Solid	20.54%	0	4.463		H	Low	Solid	20.83%	0	4.762
Cheeseburger	A	Medium	Texture	16.83%	3	4.904	Pizza	A	High	Texture	18.36%	0	5.066
	B	Low	Solid	7.78%	1	4.982		B	Medium	Texture	23.01%	2	4.723
	C	Low	Texture	12.89%	2	5.023		C	High	Texture	17.19%	0	5.029
	D	Low	Solid	18.63%	0	3.030		D	Medium	Texture	17.19%	3	5.116
	E	Medium	Texture	17.16%	4	4.895		E	High	Texture	11.11%	4	5.004
	F	Low	Solid	19.10%	0	0.055		F	High	Solid	28.89%	0	4.955
	G	Low	Texture	7.73%	3	5.093		G	High	Texture	19.58%	3	4.991
	H	Medium	Texture	9.42%	0	4.860		H	High	Texture	15.39%	0	3.988

5.3 Participants

24 English-speaking male students from the University of Tsukuba, aged 24–34 years old, $M=28.5$, $SD=3.49$ years joined this study. Initially, the experiment contemplated both male and female populations. However, due to insufficient female participation, it was decided to use only the male population data. All the participants self-reported having a certain amount of experience with food on the images.

5.4 Experimental Procedure and Evaluation Method

An online survey was conducted to investigate the impression of complexity. Participants were asked 4 questions regarding their impression of complexity of the images. Each complexity question consisted of creating a ranking (from more complex to least complex) of the 8 images that conformed each food category. This type of evaluation method was chosen because it allowed us to observe the order in which each image was accepted by the participants [19]. However, this method does not allow quantifying the differences among evaluations (between each image). In this way, the survey was created in a manner that the participants were able to see the whole set of food images for every category in a balanced form.

5.5 Results

5.5.1 Finding Significant Factors

A Logistic Ordinal Regression (LOR) analysis was conducted to investigate which factor has relevance over the subjective evaluations was conducted. Among

the different analysis methods available, LOR is an appropriate method for ranking variables which in this case corresponds to the evaluation.

The results suggested that the explanatory variable improves the LOR model because of unexplained variation, decreases from 1375.449 in the model with only a constant, to 927.133, difference 448.316 statistically significant ($p<0.001$). Furthermore, the model fit to the data, test $G^2 = 546.149$ e $\chi^2 = 527.065$, with $df's = 212$ and $sig's = 0.00$ (see Tables 4a, 4b).

Besides, the parameter analysis showed that the factor “Number of Decorative Elements” is compelling to the impression of complexity (see Table 4c). In other words, an increase or decrease of the surrounding elements on the images has a significant effect on the ranking evaluations, suggesting that the Number of Decorative Elements is a factor that significantly affects the impression of complexity.

5.5.2 Comparison with Shannon Entropy

To analyze the performance of the method, we compared the current method proposal with Shannon's Entropy index method. Spearman Rho correlation tests showed a significant positive correlation between the Number of Elements and the ranking evaluations were conducted to assess the relationship between the Number of Decorative Elements and the ranking evaluations $r_s = 0.630$, $p = 0.01$, $N = 768$, and a positive correlation $r_s = 0.462$, $p = 0.01$, $N = 768$ for the Shannon Entropy Index and the ranking evaluations (see Table 5). Although both methods resulted on positive correlations, the results suggested that the current

Table 4a: LOR Model Fit

	-2 Log Likelihood	Chi-Square	df	p-value
Intercept	1375.449			
Final	927.133	448.316	5	0.000*

*Significance at the 0.05 level

Table 4b: LOR Goodness-of-Fit

	Chi-Square	df	p-value
Pearson	546.149	212	0.000*
Deviance	527.064	212	0.000*

*Significance at the 0.05 level

Table 4c: LOR Parameter Estimates

Factor	Estimate	p-value
Camera Angle	1.202	0.094
Background	0.4	0.247
Lighting	0.011	0.375
Number of Decorative Elements	1.8	0.000*

*Significance at the 0.05 level

Table 5: Proposed method and Shannont

Method	Correlation Coefficients
Proposed Method	0.630**
Shannon Entropy Index (SEI)	0.462**

**Significance at the 0.01 level

proposal correlates slightly better than SEI. This indicates that measuring food image complexity according to the Number of Decorative Elements of the image is closer to the impression of complexity judged by the subjects.

5.6 Discussion

In this paper, we proposed a methodology for visual complexity according to the image creation perspective. By analyzing the factors that photographers commonly manipulate when creating food images, we were able to determine which factor has a significant effect on the impression of complexity. Even if the impression of complexity depends on the criteria in which people define it [9]. However, the results specifically suggested that the quantity of objects or elements has a significant effect on the impression of complexity of food images. Thus, placing or removing objects around the target food could be used as an objective measurement for food image complexity evaluation.

On the other hand, the correlation analysis between the Number of Decorative Elements and the raking evaluations showed a moderate positive correlation. Based on the study of Oliva et al. [9], this could be happening due to the heterogeneity of the images throughout the same food category. Since the images were taken from different sources, they do not consider the multi-dimensional

representation that the different visual characteristics of the food, might have over the impression of complexity. Furthermore, it was also considered that this relation might also be happening because of the type of food categories chosen for the evaluation. All the images correspond to food categories which were reported to be very familiar to the participants. Studies over the role of familiarity over the impression of complexity [19], suggest that the relationship could be affected depending on criteria used to measure complexity.

Nonetheless, the correlation comparison between the proposed method and SEI suggests that even on food images, the impression of complexity can be somewhat associated with the level of uncertainty and randomness of the image pixels, although to validate this theory, further experimentation may be required considering homogeneous food visual characteristics.

6. CONCLUSIONS & RECOMMENDATIONS

In this paper, we proposed a method to measure food image complexity from the image creation process perspective (photographer's perspective).

From this perspective, we concluded that the Number of Decorative Elements may be used as a representation for measuring the impression of complexity in food images. Meaning that in the practice, photographers could use this method to assess how complex the result (final image) may be perceived before even creating a single image. While the SEI approach could be used while the images are being created or after the images are created (as a comparison method from our proposal).

Although the samples used in the study were relatively small. It was possible to determine the importance of this method since it provides an assessment regarding which factor might affect the subjective evaluation of complexity. Furthermore, the findings allowed us to assess systematically the factors that might affect the impression of complexity.

However, this methodology proposal was not capable to assess factors such as light color from already created food images. With this in mind, we consider important to assessing this factor to observe if there is any significant effect over the impression of complexity of food images. Additionally, in this study, we tested food categories that were reported to be very familiar to the participants. Thus, it may be feasible, that the subjective evaluations may differ if the food categories are unfamiliar to the participants.

In future work, it is recommended to consider testing the effect of the sub-factors regarding the background and the position of the decorative elements, as well as the

effect of the background's light color over the impression of complexity. After all, these two sub-factors were mentioned several times during the interviews, and it could be worth looking for other effects that were not considered in this study. Finally, in future studies, it is intended to use this methodology proposal to create images with more consistent food visual characteristics to test whether the impression of complexity in food image transcends participant's age, gender, hunger, etc.

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