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The Effect of Changing Image Resolution and Modulation of Emotional Valence on Human Perception

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Abstract

Visual perception is the most extensively studied field in human perception for the practicality and explicitness of its experiments. Digital images have been used as visual stimuli and human perception are studied with certain properties of the image being changed. Although various properties of digital images have been evaluated, image resolution has rarely been selected as the independent variable in empirical research. In this paper, two experiment are proposed to evaluate the sole effect of image resolution on viewers' valence and arousal rate. Different images are chosen from IAPS and are adjusted to different resolution levels, viewers' valence and arousal rate are acquired using questionnaires. According to the result of the experiment, corresponding conclusions are provided in the paper. A strong relationship is anticipated between subjects' arousal and image resolution, indicating images of higher resolution would receive higher arousal rate. Image valence is predicted to have a more intricate relationship with image resolution, subjects' valence could increase as the resolution gets higher, and a threshold resolution may exist for valence increase, above which the subjects' valence remain unchanged. Recognition of the image would be germane to the change of arousal and valence as well.

Keywords

Image Valence; Arousal Rating; Image Resolution.

1. Introduction

Image resolution is a vital property of digital images. Low-resolution images represent elements in an image with less pixels and provide less information for viewers to interrelate the object in real life. Although direct relationship between deterioration of an image and changes in human perception has not been discovered yet, there are several factors that are affected by the image deterioration and extrapolations could be made from the research results and theories.

1.1 Complexity

To evaluate the relationship between image complexity and resolution, several researches measuring complexity in the perspective of psychology and computer science could be referred to.

In psychology studies, representations of visual complexity and factors that affect them have been investigated. Oliva et al. measured visual complexity by relating it to how difficult it is to give a verbal description of an image and how well participants remember it after a short time[1]. The result suggests that visual complexity is principally represented by the number of objects, clutter, openness, symmetry and variety of colors.

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In the perspective of computer science, various computerized measures to quantify visual complexity have been proposed. Some algorithmic measures are based on algorithmic information theory[2]. The theory postulates that the visual complexity could be depicted by the minimum code length required to describe the image[3,4]. Different compression methods have been utilized to examine their relation with complexity, for example: JPEG, TIFF and GIF compression measures[5,6] The theory suggests that simple images have redundant information that could be compressed, while less redundancy exist complex images, the compressed file size would also be bigger.

In summary, complexity and resolution are both related to information in the image. Lower image resolution causes reduction in image information and smaller file size. However, in psychophysical studies, to distinguish the difference of complexity between experiment groups, images are distinct in visual complexity and can hardly be classified to a single factor above, making predicting the specific effect of changing resolution on image perception fuzzy, regardless of its clear relevance with image complexity.

1.2 Gist Impression

The gist impression[7-9] refers to viewers' global impression and semantic description of the scene at their first glance. The rapid processing is pre-conscious and could happen in a snapshot of time. Various experiments have been conducted to study the time of recognition process[10-16]. Tolerance of human visual system to image degradation, including image distortion[17,18] and image resolution[19,20], is also studied in researches. Through eye-tracking experiments, these studies have shown that viewers' eye movement are similar when viewing images of different resolutions, which indicates that fixations of low-resolution images could predict fixation of high-resolution images. Categorization tasks for participants also proved human's ability to understand the principal meaning of an image at a very low resolution. Studies above have shown that low resolution would not affect the preliminary stage of image processing. This provides the basis for the prediction that viewers' valence of the content of an image may remain the same in a wide range of resolution, and only below a certain resolution is an image degraded and the viewers cannot fully understand the picture would their valence change greatly. As for prediction for arousal rate, results of eye-tracking experiments that high-resolution images attract fixations with longer saccade lengths [21] also suggest that the arousal rate would be higher for high-resolution images.

1.3 Fluency Theory

Fluency theory suggests that people prefer visual stimulus that could be processed more easily[22], and perceptual fluency is measured by a viewer's perception experience of ease or the speed the visual information is processed[23]. It provides an explanation for the influence of many properties on perception[24], including symmetry[25], contrast[22] and size of the stimulus[26]. As the image resolution increases, the elements in the picture could be recognized more easily. From this perspective, the relationship between fluency and image resolution is obvious, high resolution increases perceptual fluency. However, as the information increases, the speed viewers process an image would be slower, viewers' reaction to such a huge mission may vary from person to person, and the relationship is to be further discussed. Intuitively speaking, the simplification effect on information procession may dominate in perception, and the viewer may prefer images of higher resolution. A problem in fluency theory is that it predicts that the most easily processed images are the most pleasing stimuli; however, the most fluent images could also be the most boring images, which are not generally preferred by viewers. Adair, 2021[27] raised the theory of disfluency, which suggests that the disfluency arouses viewers' interest, driven by the underlying value behind ambiguity, would motivate viewers' desire to resolve it. This paper tends to amend the problem by adding disfluency as an evaluating factor. In this article, disfluency is depicted as the uncertainty, novelty and complexity of an image. From this perspective, refining an image that is clear enough for recognition would decrease the perceptive disfluency, and viewers' arousal may also decrease according to the theory.

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In summary, there are multiple properties that are related to, or could be influenced by image resolution, and some theories could partially explain the effect of resolution. However, the effect of resolution is not explicit, and the integrated effect requires direct research on image resolution.

Stevenson and Kun Guo[28] investigated how the image valence modulates the perception of low-resolution natural scenes. In their experiments, participants' gaze behavior, arousal rating and valence categorization accuracy are studied. The stimuli were selected from the international affective system[29] and divided into five groups based on their valence rates. The images are then downsized to different resolution levels, and the participants were asked to categorize the images valence and to give arousal rates of the images. Participants' viewing behavior are recorded simultaneously in this process. The result shows that for valence categorization, the image resolution has a significant main effect on categorization accuracy, with higher accuracy for image of higher resolution; for arousal rating, image resolution has a significant main effect as well, with images of higher resolution are rated higher. The research investigates the general effect of image resolution on valence and arousal and comes to a cogent conclusion. However, the research primarily focused on the modulation effect of image valence on perception, especially for low-resolution images. Moreover, resolution was only used as a standard for categorization, the exact effect of changing image resolution has not been unraveled.

To evaluate the exact effect and further investigate its principle, an exquisite experiment should be designed. In this paper, two experiment are proposed. Prediction of results and further conclusions are also included.

2. Methods

Two experiments that investigate the specific effect of image resolution on human perception is introduced in this section. The detailed experimental setup is included for researchers' reference.

1) All participants should have normal or corrected-to normal acuity;

2) Sample size should be compatible with studies in this field;

3) The study should obtain ethical approval;

4) Informed consent should be obtained from each participant.

As a reference, 20 images would be selected from the international affective picture system[29] as the stimuli of the experiments. To avoid possible effect of emotional value embedded in the image, their valence rating should range from 3 to 9 and distributed randomly in this range. The images should be controlled to be comparable on low-level image properties like brightness[30] and root mean square contrast.

In addition, to identify the effect of refining for images of different emotional value, another experiment is proposed. 15 images in total would be selected from IAPS, in which every 5 images are selected from positive, neutral or negative images. The mean valence rate of these 3 kinds of stimulus should be approximately 8, 5.5, 3, the variance of each group should be as small as possible.

The original images (1024 × 768 pixels) would be processed in Adobe Photoshop to be degraded to 4 levels of lower resolutions. Referring to the original resolution, four groups of images would be obtained by reducing the resolution by half at a time, and their resolutions are 512 × 384 pixels, 256 × 192 pixels, 128 × 96 pixels and 64 × 48 pixels. The images should be scaled back to original size (1024 × 768 pixels) using bilinear interpolation to be presented at the same size. During the experiments, the images should be displayed on the same monitor, and the distance between participants and the monitor should be controlled to be identical to ensure the visual angle are the same for all participants.

In the experiments, participants would be instructed to sit down and view the images in the way they are comfortable with. For each image selected, every participant would be shown only one resolution, and the resolution would be randomly selected. The images would be displayed in counter-balanced

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order. Each image would be displayed for 6 seconds, then the participants would be informed to fill in a questionnaire referring to Lang et al. [31] as follows:

1) If you look at a picture and you feel very aroused, excited or wide awake, pick 9. If you feel very calm, bored, or not aroused, pick 1. (Your rate should be an integer);

2) When looking at the picture, if you feel extremely pleasant, pick 9, if you feel extremely unpleasant pick 1, and if you do not have either pleasant or unpleasant feelings, pick 5. (Your rate should be an integer);

3) Did you fully understand the content (elements, topic) of the image?

The questionnaire has been modified a little bit: an extra question is added to test whether the participants understand the image content. This procedure is to specifically investigate the effect of image resolution with the prerequisite that the elements in the images are recognized and images would not be rated neutral scores for they are unclear to participants.

3. Expected Results

Although the experiment has not been conducted, conclusions could be drawn in correspondence to different results. Prediction of the specific effects of image resolution is proposed in this section.

The result of the second experiment could reexamine the behavioral research result done by Stevenson and Kun Guo[28] which showed the general effect of degrading an image by reducing its resolution is reduced arousal rating and reduced categorization accuracy of both positive and negative images. In the proposed experiment, the tendency could be more distinct: the image valence becomes more neutral as resolution reduces, which means for positive images, the valence rate would decrease, for neutral images, the valence rates would merely change a little bit and for negative images, the valence rate would increase. In Stevenson and Kun Guo[28] the decreased categorization accuracy could be explained by failure in recognition and that people tend to rate an unresolved image neutral. Separating the unrecognized result, the prerequisite that there is no cognition problem in perceiving the image is added, whether the image degradation weakened people's sensitivity to emotional value embedded in the image could be inferred from the experimental result.

In the first experiment, if the mean valence rate for all images rises monotonically as image resolution increases, higher image resolution is pleasant for human perception could be inferred. If mean valence rate changes only a little and the trend is inconspicuous, it could be inferred that the effect of changing resolution is small and unobservable in real practice. The mean valence rate may also decrease, in which situation the effect of refining of negative images dominates in the experiment. The special effect of perception for negative scenes also appeared in Stevenson and Kun Guo[28]: degrading the high-negative images had little effect on the categorization accuracy. This indicates the tolerance of human perception for degradation, especially for negative scenes. The tolerance could be explained by the nature of avoiding scenes and objects that are harmful to survival. Adding recognition as an indicator, it is predicted that only after an image is blurred enough and it could not be understood would its valence rate become neutral. For recognized images, their valence rates would only increase. The arousal rates for all images are expected to rise monotonically according to result in Stevenson and Kun Guo[28] and the rate would drop fiercely for unrecognized images.

In the second experiment, the valence rates of positive and neutral images are expected to rise as the image resolution increases. The difference in the extent by which they rise is also illustrative for the specific effect of resolution: in the case that valence rates of positive images rise more, resolution could be explained as a window in perception, which determined the emotional value that could be perceived. Also, if the valence rate of the high-resolution negative images group drops after they are clear enough for recognition, the role of resolution could be further interpreted, the emotional value embedded in the images could be blurred even when participants fully understand the image. If the valence rate of recognized high-resolution negative images increases compared to recognized low-resolution images, the increase could be interpreted as the pleasure of fluency, or explicitness in

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perceiving the image. According to Stevenson and Kun Guo[28] ,The arousal rate in the second experiment should vary from group to group, but the general trend is the same: the arousal rate would rise for all images, while rates of neutral images should rise slower compared to images bearing emotional value.

4. Discussion

In the questionnaire, it was assumed that the images are fully understood when participants answered yes in the third question, and that the participants' perception are not disturbed by failure in cognition. However, it could be argued that understanding is a rather subjective standard, which varies from person to person. It is hard to evaluate whether participants are rating with full understanding, and whether their rates would have only been affected by promotion of image quality.

Two experiments proposed in this paper merely investigated the general effect of image resolution on perception and its relationship with image valence. For further research, it would be interesting to examine which property is changed when image is deteriorated or refined, and which property has the dominant influence on perception. It would also be informative to conduct physiological experiment and see the extent to which different regions of the human brain are activated. The findings could be associated with previous research about information processing of human brain and more practical conclusions could be drawn.

5. Conclusion

Resolution is a vital property of digital images and its effect on human perception is a new direction for perceptual pleasure researches. In this paper, two experiments investigating the exact effect of image resolution on arousal and valence rate of different images are proposed. For different experiment outcomes, explanation is provided as a reference for researchers. The first experiment investigated the effect of changing resolution for images and the second experiment added image valence as an independent variable. It is assumed that image valence could be neglected in the first experiment and its role is investigated in the second experiment.

For both experiments, explanations to different outcomes are provided. In the first experiment, the mean valence and arousal rate of both recognized and unrecognized images would be informative. It is obvious that changing image resolution modulates the information people sense and people would have different reaction to different-resolution images referring to previous researches. In this experiment the general effect could be pinpointed. In the second experiment, the effect of resolution on image of different valence is investigated. This experiment would also examine some conclusions of previous experiments, the trend of rating in different image valence groups is informative for understanding in which stage of perception the information is modulated.

Being correctly conducted, this study would be a step forward in understanding how image information is perceived and arouse human emotion and more properties of human visual system processing images could be found out.

References

[1] Olivia, A., Mack, M. L., Shrestha, M., & Peeper, A. (2004). Identifying the perceptual dimensions of visual complexity of scenes. In Proceedings of the annual meeting of the cognitive science society (Vol. 26, No. 26).

[2] Donderi, D. C. (2006). Visual complexity: a review. Psychological bulletin, 132(1), 73.

[3] Leeuwenberg, E. L. (1969). Quantitative specification of information in sequential patterns. Psychological Review, 76(2), 216.

[4] Simon, H. A. (1972). Complexity and the representation of patterned sequences of symbols. Psychological review, 79(5), 369.

[5] Forsythe, A., Nadal, M., Sheehy, N., Cela-Conde, C. J., & Sawey, M. (2011). Predicting beauty: Fractal dimension and visual complexity in art. British journal of psychology, 102(1), 49-70.

[6] Marin, M. M., & Leder, H. (2013). Examining complexity across domains: relating subjective and objective measures of affective environmental scenes, paintings and music. PloS one, 8(8), e72412.

[7] Friedman, A. (1979). Framing pictures: the role of knowledge in automatized encoding and memory for gist. Journal of experimental psychology: General, 108(3).

[8] Goffaux, V., Jacques, C., Mouraux, A., Oliva, A., Schyns, P. G., & Rossion, B. (2004). Diagnostic colors contribute to the early stages of scene categorization: Behavioral and neurophysiological evidence. Journal of Vision, 4(8), 873-873.

[9] Wolfe, J. M. (1998). Visual memory: What do you know about what you saw?. Current biology, 8(9), R303-R304.

[10] Joubert, O. R., Rousselet, G. A., Fize, D., & Fabre-Thorpe, M. (2007). Processing scene context: Fast categorization and object interference. Vision research, 47(26), 3286-3297.

[11] Schyns, P. G., & Oliva, A. (1994). From blobs to boundary edges: Evidence for time-and spatial-scale-dependent scene recognition. Psychological science, 5(4), 195-200.

[12] Intraub, H. (1981). Rapid conceptual identification of sequentially presented pictures. Journal of Experimental Psychology: Human Perception and Performance, 7(3), 604.

[13] Thorpe, S., Fize, D., & Marlot, C. (1996). Speed of processing in the human visual system. nature, 381 (6582), 520-522.

[14] Fei-Fei, L., Iyer, A., Koch, C., & Perona, P. (2007). What do we perceive in a glance of a real-world scene?. Journal of vision, 7(1), 10-10.

[15] Rousselet, G., Joubert, O., & Fabre-Thorpe, M. (2005). How long to get to the "gist" of real-world natural scenes?. Visual cognition, 12(6), 852-877.

[16] Renninger, L. W., & Malik, J. (2004). When is scene identification just texture recognition?. Vision research, 44(19), 2301-2311.

[17] Röhrbein, F., Goddard, P., Schneider, M., James, G., & Guo, K. (2015). How does image noise affect actual and predicted human gaze allocation in assessing image quality?. Vision research, 112, 11-25.

[18] Watson, A. B., & Ahumada, A. J. (2011). Blur clarified: A review and synthesis of blur discrimination. Journal of vision, 11(5), 10-10.

[19] Castelhano, M. S., & Henderson, J. M. (2008). The influence of color on the perception of scene gist. Journal of Experimental Psychology: Human perception and performance, 34(3), 660.

[20] Torralba, A. (2009). How many pixels make an image?. Visual neuroscience, 26(1), 123-131.

[21] Judd, T., Durand, F., & Torralba, A. (2011). Fixations on low-resolution images. Journal of Vision, 11(4), 14-14.

[22] Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. Psychological science, 9(1), 45-48.

[23] Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience?. Personality and social psychology review, 8(4), 364-382.

[24] Oppenheimer, D. M., & Frank, M. C. (2008). A rose in any other font would not smell as sweet: Effects of perceptual fluency on categorization. Cognition, 106(3), 1178-1194.

[25] Jacobsen, T., & Höfel, L. E. A. (2002). Aesthetic judgments of novel graphic patterns: Analyses of individual judgments. Perceptual and motor skills, 95(3), 755-766.

[26] Silvera, D. H., Josephs, R. A., & Giesler, R. B. (2002). Bigger is better: The influence of physical size on aesthetic preference judgments. Journal of Behavioral Decision Making, 15(3), 189-202.

[27] Adair, H. V. (2021). Interest, disfluency, and underlying values: a better theory of aesthetic pleasure. Review of Philosophy and Psychology, 1-17.

[28] Stevenson, N., & Guo, K. (2020). Image valence modulates the processing of low-resolution affective natural scenes. Perception, 49(10), 1057-1068.

[29] Lang, P. J. (2005). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical report.

[30] Lakens, D., Fockenberg, D. A., Lemmens, K. P., Ham, J., & Midden, C. J. (2013). Brightness differences influence the evaluation of affective pictures. Cognition & emotion, 27(7), 1225-1246.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202210_8(10).0018

[31] Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International affective picture system (IAPS): Technical manual and affective ratings. NIMH Center for the Study of Emotion and Attention, 1(39-58), 3.