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Visual Impression Generation System Based on Boids Algorithm

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Abstract

There has been remarkable progress in research on well-being and well-being technology. In particular, the concept of well-being has spread to human emotion, impression and communication dimensions. In this study, we implemented visual impression generation system which allows us to express intuitively various visual impressions. To construct the visual impression generation system, we implemented an additional parameter set by focusing on multi-agent system based on Boids algorithm. The outputs of our system could generate a variety of visual impressions by inputting 8 generation parameters. We anticipate that our system can support interpersonal communication between different languages or different cultures.

Introduction

There has been remarkable progress in research on well-being (Diener et al. 1999; Keyes, Schmotkin, and Ryff 2002; Stratham and Chase 2010; Seligman 2011). Well-being has been derived from two general perspectives: the hedonic approach, which focuses on happiness, positive affect and satisfaction with life (Bradburn 1969; Diener 1984; Kahneman, Diener, and Schwarz 1999; Lyubomirsky and Lepper 1999); and the eudaimonic approach, which focuses on positive psychological functioning and human development (Rogers 1961; Ryff 1989; Waterman 1993). Research in well-being technology has attracted much attention in recent decades, for example, in the field of healthcare (Jsselsteijn et al. 2006). In particular, the concept of well-being has spread to human emotion, impression and communication dimensions (Dodge et al. 2012). Here, we aim to build an impression visualization system which can apply to well-being technology improving emotion and impression expression. Many researchers have reported that visual shapes with several factors cause us various impressions including perceptual and emotional

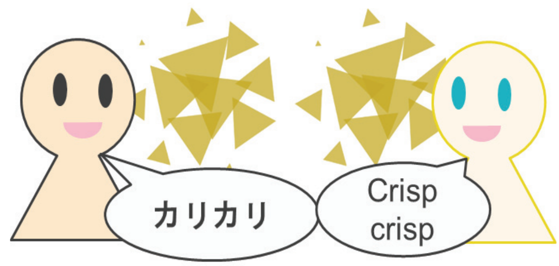


Figure 1. Intuitive Communication support by visualized impression

dimensions (Kikuchi 1971; T. Oyama 2002; F. Attneave and M. D. Arnoult 1965). Therefore, we implement a visual impression generation system to support emotion and impression expression, and communication.

The visual impression generation system could be useful for the communication among different cultures or different generations which do not have common languages. Figure 1 shows an example of the communication between Japanese and English speakers. “Kari-Kari” is a Japanese expression meaning “crispy.” The visual image associated with “Kari-Kari” is expected to support the communication between Japanese and English speakers who do not understand Japanese.

To implement the visual impression generation system, we focused on multi-agent system based on Boids algorithm. Multi-agent systems show a computerized system in which each agent interacts with its environment. Multi-agent systems have been used as a mechanism for distributed artificial intelligence (Ferber 1999). In particular, Boids algorithm is a powerful tool that allows large numbers of spatial agents mutually to interact in a physical space (Husselmann and Hawick 2008). The Boids algorithm as spatial agent-based model relies on three simple rules, which are separation, alignment and cohesion (Reynolds 1987, Reynolds 2011). However, Boids comprised of three simple rules cannot express various visual impressions. In this study, therefore, we implement an additional set to enable anyone to express intuitively various visual impressions.

System implementation

We constructed a system to generate a variety of visual impressions. According to preceding study in psychology, following attributes of images affect the impression that humans receive: compactness, complexity, symmetry, regularity, curvature, roundness, direction and the number of vertex (Kikuchi 1971; T. Oyama 2002; F. Attneave and M. D. Arnoult 1965). Therefore, we need to design such an algorithm that generates various images using these attributes in order to generate graphics of a variety of impressions. Our basic idea to fulfill the requirements is to generate graphics comprised of multiple simple figures like regular polygon or circle. By positioning the simple figures in many ways, for example, separately, cohesively, regularly, randomly, or facing same or different directions, the generated graphic may represent a variety of impressions.

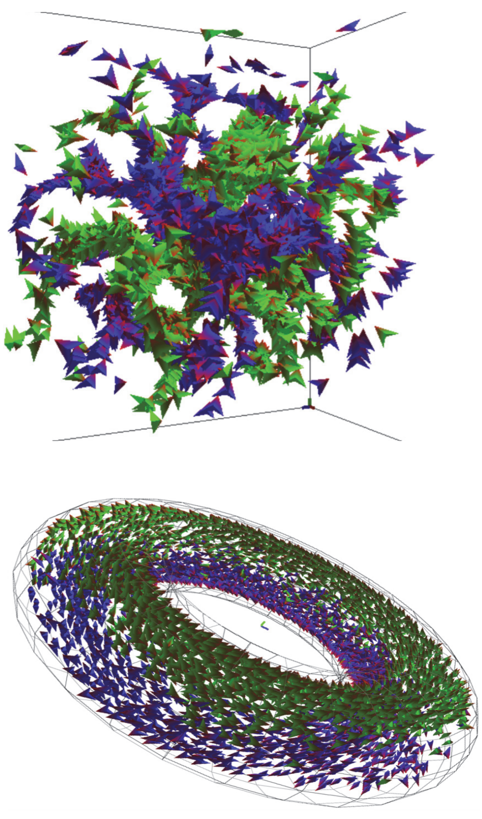


Figure 2 Three dimensional Boids simulation

In order to realize such a positioning method, we use Boids-based multi agent algorithm.

Visual impression generation method based on Boids

The "Boids" model is one of spatial agent models which simulate flocking behavior in birds and fish. It relies on decentralized and autonomous interaction of agents called "boids". Each boids has the following three simple rules of movement.

- Separation: Move to avoid crowding flock-mates.
- Cohesion: Move toward the center of flock-mates.
- Alignment: Steer in such a way to align self with the flock-mates.

These three rules cause the flock emergent behavior like bird flock. Figure 2 shows an example of Boids simulation. The flock of agents are aligned intricately, but based on rule. Remarkably, when separation force and cohesion force are balanced after several simulation steps, every agent maintain a reasonable distance each other. Consequently, they are regularly positioned.

Supposed Algorithm

The following algorithm shows our supposing method to generate image. It is based on Boids, but we devised additional parameters to show various impressions.

Algorithm 1 The visual impression generation Algorithm

Initialize agent set A with N agents whose size is different by v_s
Initialize each agent a with parameters k_s, θ, m_θ, f_d, s, c, t
while at least one agent is moving (velocity is not 0)
  foreach a in A
    Compute cohesion force f_c by relative vector
      from a to center position of others $A \setminus \{a\}$
    Compute separation force f_s by sum of vectors
      from $A \setminus \{a\}$ to a multiplied k_s and f_d
    $F \leftarrow f_c + f_s$
    Move agent position by force F
    Compute angle separation moment M by m_θ
    Rotate agent angle θ by M
  end foreach
end while
foreach a in A
  Draw shape s of a in their position with angle θ, color c and transparency t
end foreach$c$

Parameters used in the algorithm

N: Number of agents
v_s: Size difference ratio. If it is big, the size of agents differs more
k_s: Coefficient of separation force. If big, agents separate more.
θ_b: Basic angle. First agent a_1 always face this angle.
m_θ: Coefficient of angle separation moment.
f_d: Separation force difference between small agent big agent
s: Shape c: Color t: Transparency

(a) N=5, v_s=0, k_s=1, θ_b=#, m_θ=#, f_d=#, s=10, c=*green*, t=0.5

(b) N=15, v_s=0, k_s=5, θ_b=0, m_θ=0, f_d=-1, s=4, c=*yellow*, t=0.5

(c) N=15, v_s=0, k_s=1, θ_b=0, m_θ=1, f_d=-1, s=3, c=*red*, t=0.5

Figure 3. Characteristic outputs of the system.

The original Boids algorithm is executed in three-dimensional space for the sake of realistic simulation, but we use two-dimensional space to generate simple plane image. Every agent in flock has the same simple shape s like a regular polygon or a circle and the same color c and transparency t. The agents may have different size (radius) of their shape. The sizes are same when v_s parameter is 0 and differ when v_s is not 0. The directions of agents are basically specified by θ_b, but they become different when separation moment m_θ is not 0. Though boids agent use three forces, our agents do not use alignment force and use only separation force and cohesion force. This is because we do not aim to simulate movement in space but to generate a static graphic. The agents have different separation force which is proportional to their size. The constant of proportionality is described as f_d. When f_d is 0, the separation force is same and the agents' layout will be regular. When f_d is not 0 like 1 or -0.5, separation force is biased in proportion to agent's size and the layout will be dynamic. Figure 3 shows examples that the system allows us to output various visual impressions. The image (a) is composed of 5 green circles. The sizes of circles are equal and aligned regularly. It may give stable, soft or gentle impression. The image (b) is composed of many yellow squares with different sizes. In addition, they are positioned separately because separation force is set to relatively big number (**k_s=5**). The image give lightweight, and bright impression. The image (c) is composed of red triangles with different size and direction which gives powerful, fierce or angry impression.

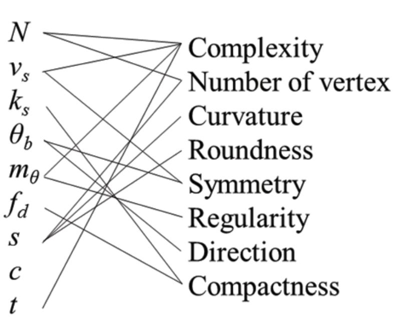


Figure 4 Correspondence between generation parameters and image attributes.

Detailed description of each parameters

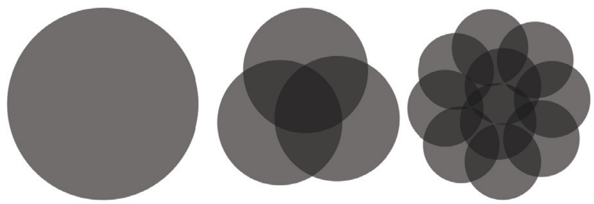
Each parameter of the system is designed to affect output impression. In this section, we describe each parameter and their effects to image attributes. Figure 4 shows the correspondence between generation parameters and image attributes. Table 1 shows the outputs of the system. The impression gradually changes when each parameter varies.

The number of agents $N \in \mathbb{N}$ is related to "complexity" and Number of vertex. Obviously, the more number of objects increase, the more "complex" impression will be raised. Size difference ratio $v_s \in [0,1]$ is a parameter which decides the size of each agent. $s(a_i) = s_b(-2v_s\, i/N + 1 + v_s)$ where $s(a_i)$ is size of agent a_i and $s_b$is basic size. When v_s=0, the sizes of agents are all equal (s_b). When $v_s \neq 0$, the size of agent a_i decrease with increasing i. Separation $k_s \geq 0$ is coefficient of separation force which makes agents to try to avoid each other. The cohesion force which conflict with separation force is fixed to small value, so basically k_s regulates distance between agents. k_s is supposed to affect "compactness" of whole image. The basic angle $\theta_b \in [0,1)$ is the direction of agent when agent has directional shape (not circle). When $\theta_b = 0$, a corner of shape faces up, and when $\theta_b = 0.5$, an edge faces up. This parameter affects "symmetry" and "direction". Angle separation moment m_θ is a moment which makes agent try to face different direction from others. When $m_\theta = 0$, all agents face same direction θ_b, and when $m_\theta = 1$, agents faces completely different direction. m_θ affects "regularity" or "complexity". Force difference $f_d \in [-1, 1]$ is a little difficult to understand. Basically ($f_d = 0$), agents' position is regularly aligned no matter the size is because separation force and cohesion force balances. However, when the sizes of agents are different ($v_s \neq 0$), big agents and small agents should not be aligned randomly. However, it is possible to align with the following rules such as "the smaller the size is, the stronger the separation force is" or "the bigger the size is, the stronger the separation force is". As a result, the parameter f_d controls density which is related to "compactness". Shape $s \in [3,10]$ indicates agent's shape such as regular polygon or circle ($s = 10$). It affects "roundness", "curvature" and "number of vertex". Transparency t may affect shape impression. When many agents are overlapped, transparent agent makes complex image, so transparency t affects "complexity"

Examples of generated images using each parameters

Table 1. the relations the generated images and each parameters

N: Number of agents

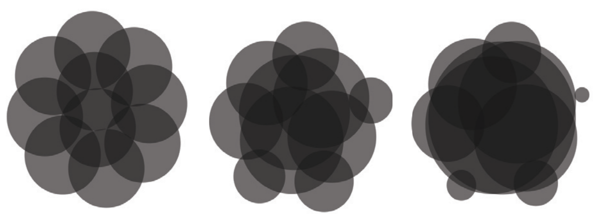


N=1 N=3 N=10

Other conditions:

v_s=0, k_s=1, θ_b=#, m_θ=#, f_d=#, s=10, c=*black*, t=0.5

v_s: Size difference ratio. If it is big, the size of agents differs more

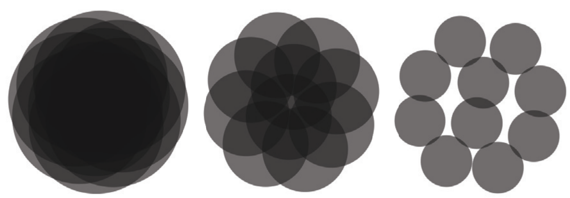


v_s=0 v_s=0.5 v_s=0.5

Other conditions:

N=10, k_s=1, θ_b=#, m_θ=#, f_d=-1, s=10, c=*black*, t=0.5

k_s: Coefficient of separation force. If big, agents separate more.

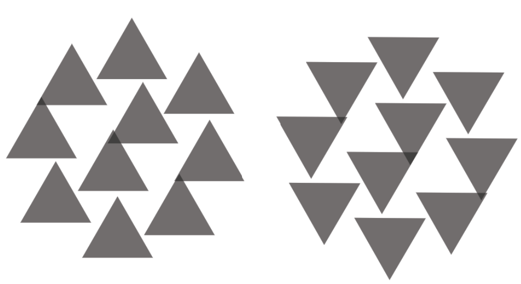


k_s =0.1 k=1 k=5

Other conditions:

N=10, v_s=0, θ_b=#, m_θ=#, f_d=#, s=10, c=*black*, t=0.5

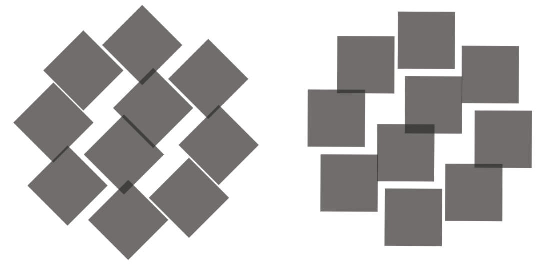
θ_b: Basic angle. First agent a_1 always face this angle.



θ_b=0 θ_b=0.5

Other conditions:

N=10, v_s=0, k_s=1, m_θ=#, f_d=#, s=3, c=*black*, t=0.5

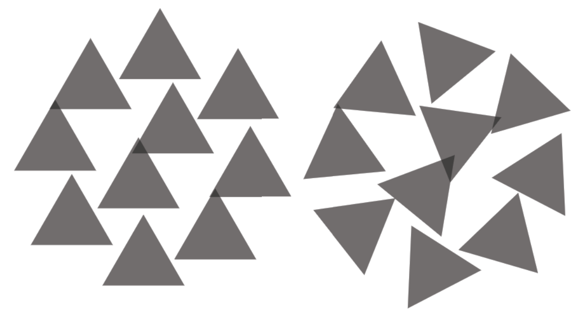


θ_b=0 θ_b=0.5

Other conditions:

N=10, v_s=0, k_s=1, m_θ=#, f_d=#, s=4, c=*black*, t=0.5

m_θ: Coefficient of angle separation moment.

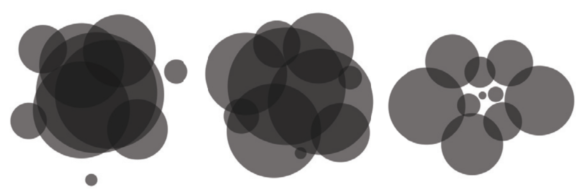


m_θ=0 m_θ=1

Other conditions:

N=10, v_s=0, k_s=1, θ_b=0, f_d=#, s=3, c=*black*, t=0.5

f_d: Separation force difference between small agent big agent



f_d =-1 f_d =0 f_d =1

Other conditions:

N=10, v_s=1, k_s=1, θ_b=#, m_θ=#, s=10, c=*black*, t=0.5

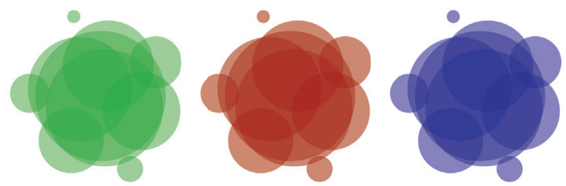
s: Shape

s =3 s =4 s=10(circle)

Other conditions:

N=#, v_s=0, k_s=1, θ_b=#, m_θ=#, f_d=#, s=10, c=*black*, t=0.5

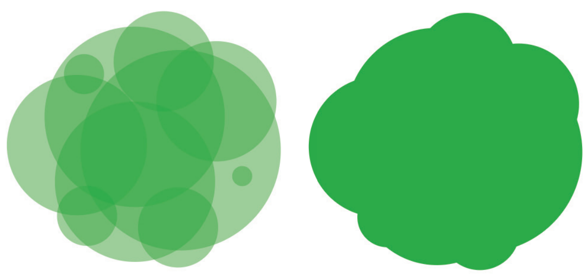
c(h,s,v): Color



c=green *c =red* *c=blue*

Other conditions:
N=10, v_s=1, k_s=1, θ_b=#, m_θ=#, f_d=-1, s=10, t=0.5

t: Transparency



t=0.5 t=1

Other conditions:
N=10, v_s=1, k_s=1, θ_b=#, m_θ=#, f_d=-1, s=10, c=*green*, t=0.5

Future works

In this paper, we constructed a system to visualize various visual impressions by 8 parameters. As shown in the previous section, we need to verify whether outputs of our system convey sufficiently various impressions. It is also necessary to quantify the visual impressions. After evaluating our system, we want to create a system which automatically generate various images through the quantified values of visual impressions. Impression can be evaluated by [-1, 1] value between pair of adjectives. For example, -1 value of "hard-soft" adjectives mean "very hard". 0 means "neither". This is called semantic differential (SD) method, which is usually used to represent human impression of some objects. It is based on a hypothesis that the human impression can be represented as many pair of adjectives. Therefore, we will use SD method to evaluate our system.

The parameters of visual impression generation system are designed by the relations between image attributes and the output of the system. It is supposed to be correlated with impression values. Thus, we suppose that it is possible to map impression values to image generation value. Figure 5 shows the load map of system implementation. As we already constructed the system to generate image by 8 parameters, next we construct a mapping system which inputs impression values and outputs image generation parameter. As a whole system, it generates image of any impression.

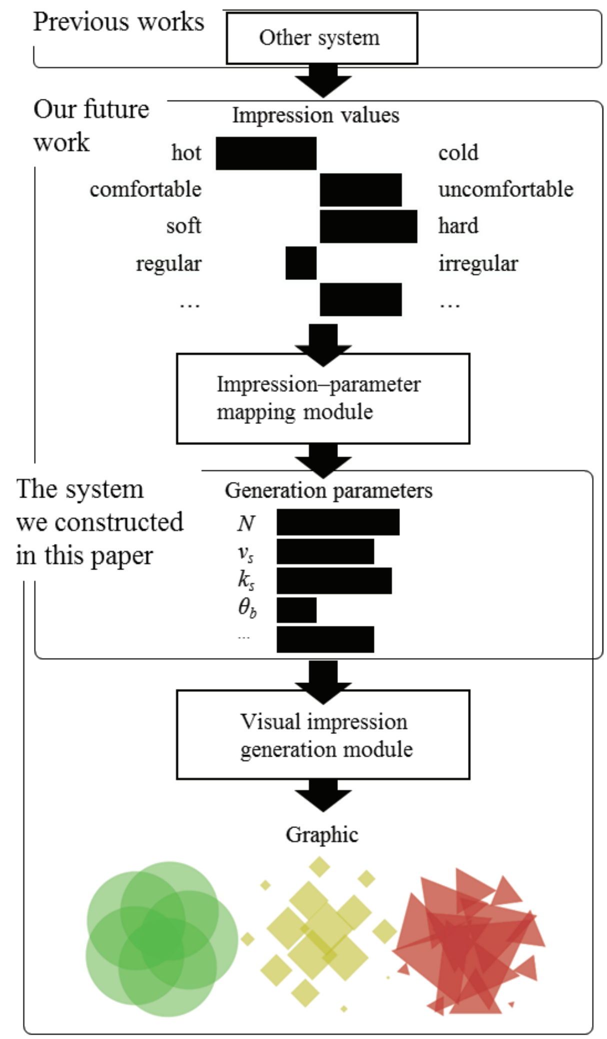


Figure 5. System construction load map.

In order to build the mapping system, we are going to perform a psychological experiment to measure the impressions of characteristic images which is outputted by the system. The obtained data means the impression value which the generated image brings. Consequently, we can construct the mapping system expressing the relations between impression values and image generation parameters. Figure 6 shows the design of the mapping system. This system enables to visualize intuitive impression. Especially, we suppose that it is useful to visualize fine nuances of language such as onomatopoeia (i.e. sound symbolic word) which have a direct link between sound (phonological form) and perceptual (or semantic) meaning. In other words, although people speak different languages, our system can be used in the communication situation by using the fine nuances generated by various images (Figure 7).

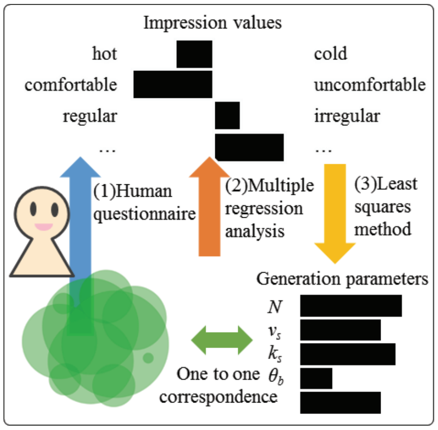


Figure 6. The design of impression-parameters mapping modules

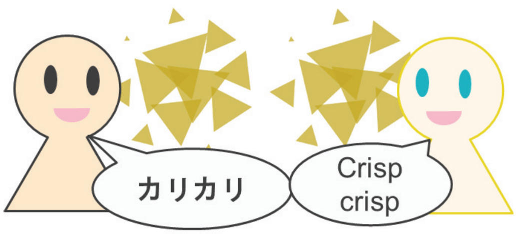


Figure 7. An use case of the system:

Conclusion

We constructed the visual impression generation system by focusing on multi-agent system. To construct the system, we implemented an additional set for enabling to express the various visual impressions. As a result, we could generate images with various visual impressions. We believe that this system is useful in expressing various visual impressions and will prompt research on future communication technology based on visual impressions.

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