ORIGINAL ARTICLE

A Study on the Expression of “A sense of being alive”
– Flashing Lights, Sounds, and Changing Forms of the Artifact –

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Abstract: This current research presents the elements of expressing a sense of being alive of the artifacts based on the results of three experiments. In recent years, robots and AI have become necessary products in the world, and there are the considerations of designing artifacts to express a sense of being alive by making them similar to humans. However, the received data about making the artifacts have a sense of being alive are only related to the abstract concepts, which are difficult to apply. Therefore, this study aims to determine the factors of the expression of a sense of being alive of the artifacts by performing comparisons between the expressing of a sense of being alive and the mechanical expression of the artifacts. Then, three experiment phases were conducted, which were a study on artificial expression via flashing lights, sounds, and changing forms. A set of questionnaires were distributed to the participants. The participants’ points of view were examined by employing multivariate analysis methods. The transition of the artificial expression in this research was turned into the figure of waveforms. Finally, four factors were selected as having the highest effect with expressing a sense of being alive from the human judgments, which were 1) the waveform with some fluctuations, 2) smooth waveforms, 3) an unexpected waveform, and 4) the waveform with unstable periods. This study’s results may further be applied to new products to allow them to express a sense of being alive.

Keywords: A sense of being alive, Expression, Product design

1. INTRODUCTION

Nowadays, robots have already become a part of daily human life. Some robots were designed to have an appearance similar to a living thing. In contrast, humans feel fear in connection with them due to their lack of ability to express a sense of being alive based on human perception. However, the process of making robots that can express a sense of being alive is difficult to develop and apply. Research in this field is also conceptual. Hence, this present research aims to determine the factors related to expressing a sense of being alive of the artifacts from the opinions of humans opinions regarding the alternative ways for developers to produce robots or other artifacts in the future.

The industrial robotics are predicted to continue rising significantly in the near future, especially service robots, according to the Japanese Ministry of Economy, Trade and Industry report in 2010 [1]. Previously, robots with a mechanical form were reported as “difficult to connect with” and “cold”. Therefore, it was recommended that the physical appearance of the robots be transformed to be closer to a lifelike appearance following the development of Human-Robot Interaction [2, 3]. Although the appearance of robots may too close to that of an organism, if it is still distinct from that of a creature, this could lead to the uncanny valley phenomenon, which has been declared as a repulsive outcome [4]. An example is the emotional reaction of visitors when they saw the Geminoid HI-1, the anthropomorphic robot that has an external look similar to the outward appearance of the creator Prof. Hiroshi Ishiguro. The visitors felt scared, which is one of the prevailing feelings related to the uncanny valley’s hypothesis [5]. This happens in both the human-like robots and the artifacts close to the human figure. In this study, the meaning of “artifacts” refers to things made by humans, such as robots, machines, art, and digital content, that were produced by using machines and technology. In order to avoid the uncanny valley’s outcomes, the designers and developers are providing the artifacts with an appearance that is more like a machine’s. Therefore, this raises the question of whether the robots or artifacts in the form of non-living things can express a sense of being alive or not.

From the explorational study presented here, we address the question that, if the artifacts have an external appearance distinctive from a living thing, such as in the machinal or geometric forms, what is the process to make them express a sense of being alive? First, an overview about how to make the artifacts express a sense of being alive is discussed here; the previous studies pointed out that combining bio-inspiration with the artifacts makes them express a sense of being alive. For making humans believe that artifacts can express a sense of being alive, the appearance was found to be less important than behavior. As such, an artist named Klein combined a sense of biology
into his living sculpture to make the spectators observe a sense of being alive through his artwork [6]. Similarly, the cybernetic sculpture named “The Senster” created by Ihnatowicz in 1970 could make the audience feel that it was similar to a living thing because it possessed random behavior and moved freely [7]. Furthermore, the kinetic sculptures called the “Strandbeests” created by Jansen in 1990 looked similar to an organism because they could move independently without any external support and had complicated features to survive in dangerous areas [8]. Notwithstanding, the received information did not produce the experimental data based on personal opinions.

Hence, in this study, identifying the factors that express a sense of being alive of artifacts is proposed, and the focus is on the expression that is in physical mobility and motion, for example, the motion of sounds or flashing lights. To achieve these objectives of the study, three experimental phases of the artificial expression were conducted with forms, which were 1) Experimentation for the rhythm of lights, 2) Experimentation for the rhythm of sounds, and 3) Experimentation for changing forms. Then, the multivariate analysis methodology was used to determine the differentiation among all of the expressions. After that, the factors related to the expression of a sense of being alive of the artifacts were discussed. In the present research, the transition of artificial expression is illustrated in the visible figures that are in the waveforms. As a concrete result, the creators can efficiently utilize and develop their products to express a sense of being alive even though the appearance of the artifacts differs from that of a living thing, so the comprehension of the factors related to expressing a sense of being alive from the artifacts may be further developed in the future research.

2. OVERVIEW

The objectives of this research were to determine the definitions and characteristics of organisms and machines in order to design the survey questions and the simulations in the experiments. For “machines”, according to the Oxford Advanced Learner’s Dictionary fifth edition, the definition is “1. (often in compounds) an apparatus with several moving parts, designed to perform a particular task; 2. a group of people that control an organization, etc., 3. a person who acts automatically without having to think or show any feeling.” Additionally, it should be noted that machines do not have independence or features of originality.

From the exploration of the information, it was found that the machines possess the elements that are opposite to those of an organism. The simulation of artificial expression was designed based on the expression of the machine, which is in contrast with the organism’s expression, such as expression in the sequences and stable rhythms that do not demonstrate any independence or fluctuation. The living being’s characteristics that make them separate from non-living things are nutrition, respiration, movement, excretion, growth, reproduction, and sensitivity [9]. From these features, movement was one of the natural qualities that causes people to easily recognize a sense of being alive because all living things can move without any external help, such as the movement of a human’s chest when breathing or locomotive movement, which means moving from one place to another [10]. An example is when leeches are crawling or making an inching movement in looping cycles [11]. As stated in the previous section, these features are necessary processes of living things that are the bioinspiration for the development of robots and artifacts that make the viewer observe a sense of being alive. Likewise, Row stated that an object which included lifelike movements could make the spectators observe a sense of being alive. Furthermore, Row also identified that the four characteristics that produce a sense of being alive are: physical appearance, dynamic behavior, user recognition, and independence [12]. Independence can be specified as self-determinability. The robots that move independently might look like they have consciousness the same as living things. For example, this was shown in the case of an insect’s movement. The movement of insects is directed by using independent control systems and legs [13]. Moreover, anthropomorphic behavior is considered for applying human characteristics to non-living things [14]. In some plants, this behavior is also found when they turn their leaves toward the sunlight, so as to thrive and survive. As such, this type of plant appears to exist more widely than others [15]. Hence, this behavior can make humans observe their minds more clearly than they see their material forms [16]. Based on the literature review, it can be summarized that the living things have their characteristics and independent expression that may make humans recognize or have a feeling that expresses a sense of being alive from them.

First, the literature on the definition of “organism” was reviewed. According to Oxford Advanced Learner’s Dictionary 5th Ed. (1995), “Organism” was defined as “1. (a) a living being, especially a tiny one, with parts that work together, (b) an individual plant or animal; 2. a system composed of elements which are dependent on each other”. The living being’s characteristics that make them separate from non-living things are nutrition, respiration, movement, excretion, growth, reproduction, and sensitivity [9]. From these features, movement was necessary processes of living things.
3. METHODOLOGY

In order to determine the factors that express a sense of being alive of the artifacts, this study aimed to measure the differentiation between the “expressing a sense of being alive” and the “mechanical feeling” from the participants’ point of view.

The experiment was conducted in three phases, which focused on the study of one expression in physical mobility and two artificial expressions in motion. Moreover, all of the artificial expressions in the experiments were concerned with being able to be produced by waveform control.

Phase (1) Experimentation for the rhythm of lights: In this first phase, the focus was on investigating the level of the participants’ perception after watching the simulation’s expression via producing flashing light signal rhythms. Providing the flashing light signals was considered as one type of artificial expression. The robots or machines produced the flashing light signals after receiving the user’s commands. Phase (2) Experimentation for the rhythm of sounds: In the second phase, the aim was to examine the artificial expression by utilizing sounds, which can be defined as the principal method of human communication. Recently, there have been increasing numbers of machines that use sounds for communication with humans. Phase (3) Experimentation for changing forms: In this phase, the focus was on evaluating the simulation of the artifact’s changing form. The living things cannot change their form independently, but machines have this ability. Moreover, this study focused on the changing forms of the robot in the new formats, which may have significant benefits for the design of new robots.

For evaluating the artificial expression in these experiments, two survey questions were conducted to identify the factors by comparison between expressing a sense of being alive and a mechanical feeling. Then, the participants’ evaluation from their feelings were measured by employing a 7-point Likert scale (from 1 = “highly observe mechanical expression” to 7 = “highly observe a sense of being alive”). The evaluation of the outcomes of the experiments was performed using multivariate analysis. The Microsoft Excel program and JMP software version 11 (SAS Institute, USA) were utilized to examine the strong factors due to the diversity of the sample’s elements. This investigation of these experiments will provide advantages to the development of an artificial expression for robots or products, such as the artifacts that can perform interaction and/or communication with humans.

4. EXPERIMENT

4.1 Phase 1. Experimentation for the rhythm of light

4.1.1 Simulation

Firstly, the factors were considered to design as simulations based on the expression of the electronic devices as follows:

Factor 1. The waveforms with some fluctuations or without any fluctuations.

Factor 2. Having random rhythms or routine rhythms: The waveforms with the random rhythms or the waveforms in the routine that refer to the waveform in stable rhythms. The stable rhythms are often seen in the machine’s actions.

Factor 3. High- or low-frequency: The frequency of the waveform was set from 0.16 to 3 Hz (Low to high-frequency).

Adobe After Effect software was used to produce the simulations of artificial expression in this study. The method of creating samples of flashing light rhythm was designed by using black and white images. The white image refers to lightness in one hundred percent with completely opaque, and the black image refers to darkness in zero completely transparent. Therefore, both images were arranged and adjusted in various ways due to the above factors. Finally, the images were exported in the video file within 30 seconds.

4.1.2 Apparatus

A total of 27 simulation of artificial expression were created using Adobe After Effects CC Software, version 15.1 (Adobe system incorporated, USA). The samples were displayed in the video in size 1280 x 720 pixels with a resolution of 720p and 30 seconds in length. A personal portable laptop (Intel Core i7, 2.2 GHz, 16 GB) was used to operate programs and collect data. In addition, Typeform Software: An online survey software was employed for the e-questionnaire.

4.1.3 Analysis methods

This study conducted multivariate analysis to analyze participants’ answers which are cluster analysis and principal component analysis. These methods demonstrated the tendency of how participants feel a sense of being alive from the expression of the artifacts.

4.1.4 Participants

The participants in this phase were ninety-one participants. The participant who had epilepsy was excluded from participating in this test due to exposure to flashing lights that could trigger a seizure.
4.1.5 Results

1) Stage 1: Cluster analysis

The cluster analysis was used to group a set of similar data according to the information was found in the data [17]. A set of artificial expressions was generated within a smaller group depending on the relationship of each expressing transition. The transition in this study was turned into the waveform figures in Figure 1. There were a total of 27 samples were analyzed into six characteristics group which were; A (Written in red): The triangular waveforms with various wavelengths. B (Written in red): Most of the waveforms have repeated wave rhythms. C (Written in green): The low-frequency smooth waves within three-second and six-second wavelengths. D (Written in green): Multiple low-frequency waves with some fluctuations. E (Written in blue): The square waves with various kinds of wavelengths. F (Written in blue): All of the waveforms were high-frequency triangular waves in one-second wavelengths.

2) Stage 2: Principal components analysis

This study analyses the artificial expression by providing a flashing light utilizing two dimension PCA plot to generate the differentiation and similarity of 27 samples. Principal component analysis (PCA) was defined as a valuation method for learning relations in continuous multivariate data and a tool for describing the information’s variance-covariance structure [18]. This study examines using plot to show datasets of artificial expression by providing a sense of being alive graphically. Figure 1 displays a PCA plot of the data of the simulations. Principle component 1 (PC1) 25.1%, and Principle component 2 (PC2) was 8.4%.

- On the left side on the x-axis, we find the waveforms in hard formations with high-frequency waves. Besides, most of the waveforms were a one-second wavelength.
- On the right side on the x-axis, it appears the waveforms comprised of low-frequency waveforms with some fluctuations. Most of the wavelengths in this group were three seconds and six seconds.
- On the top of the Y-axis, we can see that the waveform that included some fluctuations.
- On the bottom of the Y-axis, It is discovered that the waveforms did not contain any fluctuations.

The data illustrates a group of the waveforms that were mostly selected as expressing a sense of being alive was no. 8, 21, 27, and 9, with the average value of 5.12, 4.95, 4.93, and 4.87, respectively. On the other hand, the waveforms no. 4, 5, 10, and 25 with the average value of 2.23, 2.63, 2.93, and 2.99 were mostly chosen as representing a mechanical feeling from the participants’ point of view. The results of a two-tailed test show a significant differentiation in the comparisons. The p-value is less than 0.01 (P<0.01).

4.1.6 Consideration of the experimentation for the rhythm of light

The characteristics of the waveforms, which were considered as the group of providing a sense of being alive were specified as follows: 1) Smooth wave, 2) Low-frequency waveform: The average frequency of the waveforms mostly selected as providing a sense of being alive was about 0.16 - 0.66 Hz, 3) The waveforms with some fluctuations, and 4) Difficult to predict: The waveforms consisted of various wavelengths and wave rhythms. On the other hand, the group of waves, which was considered as expressing a machine feeling to the participants was

![Figure 1](image_url): The first and second principle components of the experimentation for the rhythm of light with clustering

Note: The number of the waveforms with each average value
specified as: 1) A large number of waveforms in this group showed the waves to be square or triangular, 2) The waves comprised a high-frequency, 3) Most of the waveforms were a one-second wavelength, and 4) The actions of the waves were easy to predict; such as a repeated waveform.

4.2 Phase 2. Experimentation of the soundwave

4.2.1 Simulation

The samples of artificial expression were 22 simulations in this experiment. The four elements were selected based on expressing the voice sound by electronic devices as follow:

Factor 1. Non repeated or repeated waveforms.

Factor 2. Many note pitches or few note pitches: The soundwaves consisted of many note pitches, or the soundwaves comprised of few note pitches.

Factor 3. The soundwaves included some fluctuations or the soundwaves without any fluctuations.

Factor 4. Consisting of some elements that could represent the expression of an organism or without these elements: The soundwaves that consists of the expression of an organism, such as, similar to human breathing.

The soundwaves which used as the simulations in this study were built by the Vocaloid program. The Vocaloid program was known as the singing voice synthesizer software. In this experiment, we selected one sound from the voicebank of the cyber songman and modified the chosen sound in the buzzing sound. The buzzing sound in this study refers to an electronic buzzing sound. Then, the buzzing sounds were arranged in multiple forms due to the factors which were stated before. In addition, we have created a vibrating tone and customize the waveform of the sound. Finally, the soundwaves were exported in the video file within 6 seconds.

4.2.2 Apparatus

A total of 27 simulations of artificial expression was produced by the Vocaloid Software, version 5 (Yamaha Corporation, Japan). The sound from the voicebank of a cyber songman was modified to provide artificial sounds. The sample represented in the video in size 1280×720 pixels, and each video length was in 6 seconds. This phase used a personal portable laptop (Intel Core i7, 2.2 GHz, 16 GB) to run programs and gathering data. This study also used Typeform Software for the e-questionnaire.

4.2.3 Analysis methods

This study conducted cluster analysis, principal component analysis, and factor analysis to examine participants’ answers.

4.2.4 Participants

The participants in this experiment were forty people. All subjects were required to sit in a silent place while doing the survey and prepared headphones to listen to the sample’s videos.

4.2.5 Results

1) Stage 1: Cluster analysis

The cluster analysis divided the 27 artificial expression simulations into three groups which were A, B, and C in Figure 2. The expression in this study was turned into the rhythms of the soundwave. Firstly, A (Written in red): The square waves with a smaller number of note pitches. The minimum number of notes was one, and the maximum number of notes was two. B (Written in green): The combination of one tone and acoustic waves. The minimum number of notes was one, and the maximum number of notes was five. C (Written in

![Figure 2: The first and second principle components for the experimentation of soundwave with clustering](image-url)
blue): Various waveforms with multiple notes and some fluctuations. The minimum number of notes was two, and the maximum number of notes was six.

2) Stage 2: Principal components analysis
The study employed PCA plot to display the data of artificial expression using sound. In figure 2 shows the datasets of artificial expression through sound. Principle component 1 (PC1) 50.2%, and Principle component 2 (PC2) was 8.42%.
- On the left side on the x-axis, It appears a group of square waveforms. All of the waveforms in this group had fewer notes. The minimum number of notes was one, and the maximum number was two.
- On the right side on the x-axis, we discover a group of waveforms with some fluctuations that had various note pitches. Furthermore, most of the waves in this group were unpredictable. The minimum number of notes was two, and the maximum number was six.
- On the top of the Y-axis, we find the waveforms were composed of acoustic waves.
- On the bottom of the Y-axis, It is discovered a group of the frequency waveforms, which consisted of one-second and three-second wavelengths. Most of the waves in this group had a fewer number of notes.

From the received data, the waveforms no. 4, 3, 25, 20, and 10 with the average value of 6.08, 5.83, 5.45, 5.43, and 5.43, respectively, were mostly selected as expressing a sense of being alive from the participants’ perception. In contrast, the waveforms no. 19, 17, and 9 with the valuation of 0.84, 0.74, and 0.72. On the other hand, The low value was waveforms no. 3, 4, and 24 with the valuation of -0.50, -0.41, and -0.36. The highest value was detected as comprised of few note pitches. The low-value waveforms consisted of many note pitches.

3) Stage 3: Factor analysis
Figure 3 displays the factor analysis generated four factors that described a total of the variance for the variables set were 50.71%.

Factor 1: The variance defined by this first factor was 15.4% according to figure 3. The high-value waveforms were waveforms no. 19, 17, and 9 with the valuation of 0.84, 0.74, and 0.72. On the other hand, The low value was waveforms no. 3, 4, and 24 with the valuation of -0.50, -0.41, and -0.36. The highest value was detected as comprised of few note pitches. The low-value waveforms consisted of many note pitches.

Factor 2: This factor described the variance in 15%.
It appears that the high-value waveforms were waveforms no. 25, 20, and 10 with the valuation of 0.74, 0.70, and 0.67. The low-value waveforms were the waveforms no. 13, 1, and 26 with the valuation of -0.41, -0.36, and -0.25. The waveforms in the high value consisted of some fluctuating waves. In contrast, the waveforms in the low value did not show any fluctuating waves.

Factor 3: The variance explained in this factor was 10.7%. The high-value waveforms were waveforms no. 7, 8, and 1 with the valuation of 0.70, 0.54, and 0.53. The low-value waveforms were the waveforms no. 15, 26, and 23 with the valuation of -0.59, -0.43, and -0.20. The high value waveforms reflected the rhythm of the breath of a living thing. The low value waveforms contained the waves that did not express any breathing rhythms.

Factor 4: The fourth factor is defined as 9.61%. The high-value waveforms were waveforms no. 12, 23, and 13 with the valuation of 0.81, 0.61, and 0.39. The low-value waveforms were the waveforms no. 3, 11, and 8 with the valuation of -0.52, -0.50, and -0.48. The high values was analyzed as comprised acoustic waveforms. The waveforms in the low values did not consist of any acoustic waves.

4.2.6 Consideration of the experimentation of the soundwave
The characteristics of the waveforms related to the ability to express a sense of being alive were specified as follows:
1) The waveforms with some fluctuations, 2) Represent the breathing of a living thing: The rhythms of the waveforms were similar to the breathing of living things; such as, inhaling or exhaling, and 3) Difficult to predict the action of the waveforms: The waves were not in a sequence. In contrast, the waveforms that were examined as could be highly expressed as mechanical feelings were determined as follows: 1) The group of the waveform that comprised only a few note pitches, 2) The square-shaped waveforms, and 3) The waveforms in a sequence that was easy to predict the action of the waveforms.
4.3 Phase 3. Experimentation for changing form

4.3.1 Simulation

There were 22 simulations of artificial expression by changing form. The simulations were formed by the factors related to the changing forms from the electronic fan controllers and make various waveforms depends on two factors as follows:

Factor 1. The waveforms with some fluctuation or without any fluctuations.

Factor 2. The waveforms including random rhythms or without random elements.

In this study, two motor powers were used: One fan was built as simulating the inhalation, and the other fan was used as simulating the exhalation. The fans’ motor powers were programmed by imputing the numeric methods of the equation of motion, including the random variables. We consider numerical methods for the operation of fans.

4.3.2 Apparatus

There were 22 simulations of artificial expression through the robot’s changing form. Figure 4 shows samples of this experiment. The body of the robot was produced by 0.01-millimeter plastic sheets. There are two fans used to represent the rhythms of breathing, such as inhaling and exhaling inside the robot’s body. In addition, the Arduino Uno rev board and Arduino software IDE, version 1.8.9 (Arduino LLC, USA) were applied to control the robot. The Nikon D600 was used as a camera to record the samples of the robot’s expression. The samples were displayed in the video in size 1920 × 1080 pixels with a resolution of 1,080 pixels, and each sample video was 00:52 wavelengths. A personal portable laptop (Intel Core i7, 2.2 GHz, 16 GB) was used to operate programs, an Arduino board, and collect data. Also, Typeform Software was used for the e-questionnaire.

4.3.3 Analysis methods

This study conducted cluster analysis, principal component analysis, and factor analysis to examine participants’ answers.

4.3.4 Participants

Forty-six participants participated in this experiment.

4.3.5 Results

1) Stage 1: Cluster analysis

The cluster analysis generated the 22 samples into three groups which were A, B, and C in Figure 5. First of all, A (Written in red): The low-frequency waveforms. B (Written in green): The medium frequency waveforms in sequence. C (Written in green): Multiple kinds of waveforms, but most of the waveforms in this group were in sequenced rhythms. D (Written in blue): The high-frequency waveform with some fluctuations. E (Written in blue): The sequenced waveforms, which had some fluctuations.

Note: The number of the waveforms with each average value

Figure 5: The first and second principle components for the experimentation for changing form with clustering
2) Stage 2: Principal components analysis
In Figure 5, it presents the datasets of artificial expression by changing form. Principle component 1 (PC1) was 26.1%, and Principle component 2 (PC2) was 9.41%.
- On the left side on the x-axis, we found a group of low-frequency waveforms in sequenced rhythms.
- On the right side on the x-axis, it can be seen that a group of high-frequency waveforms with noisy rhythms.
- On the top of the Y-axis, it is discovered that the group did not include any fluctuations.
- On the bottom of the Y-axis, we can see a group of waveforms with some fluctuations.

The data shows the waveforms no. 6, 21, 2, 18, and 14 with the average value of 5.11, 5.02, 5.02, 4.96, and 4.85 were mostly selected as providing a sense of being alive from the opinions of the participants.

3) Stage 3: Factor analysis
Figure 6 displays the analysis yielded four factors explaining a total of 64.9%.

Factor 1: The variance explained in this factor was 21%. The high-value waveforms were waveforms no. 10, 3, 12, and 8 with the variation of 0.779, 0.769, 0.766, and 0.675. In contrast, the low-value waveforms were the waveforms no. 22 and 17 with the variation of -0.037 and -0.018. The waveforms in the high value were analyzed as having stable periods. On the other hand, the group of waveforms in the low value had an unstable waveform period.

Factor 2: The second factor was explained as 18.9%. The high-value waveforms were waveforms no. 21, 18, 6, and 16, with the variation of 0.805, 0.789, 0.757, and 0.744. The low-value waveforms were waveform no. 8 with a variation of -0.15. It is considered that the high-value waveforms are achieved by having strong random elements, and the waveforms in the lowest rate group were not incorporated with any strong random factors.

Factor 3: The variance described in this factor was 12.5%. The high-value waveforms were waveforms no. 19, 13, and 11, with the variation of 0.761, 0.712, and 0.500. In contrast, waveforms no. 9, 2, and 1 were in the group of the lowest value with the variation of -0.12, -0.037, and -0.035. The high value was considered as including some fluctuations. However, the figure of the waveforms in the low value did not have any fluctuations. Although waveform no. 2, which was shown in the low rate group, had some fluctuations in the graph, the waveforms in the sample video did not clearly represent any fluctuations.

Factor 4: The fourth factor was defined as 9.61% from the variance. The high-value waveforms were waveforms no. 2, 22, and 5 with the variation of 0.738, 0.531, and 0.427. For the waveforms in the low value were the figures of waveform no. 9 and 10 had a variation of -0.60 and -0.27. The high rate value was assumed to be achieved from strong noisy waves. On the contrary, the group of low rate did not comprise any strong noisy waves.

4.3.6 Consideration of the experimentation for changing form
The characteristics of the waveforms, which were considered as a group of providing a sense of being alive in this experiment were specified as follows: 1) Unstable waveform period, 2) Having strong random elements, 3) Consisting of some fluctuations, and 4) Including some strong noise. On the contrary, the group of waveforms that were analyzed to provide a mechanical feeling was specified as follows: 1) The waveforms with stable period, 2) Having weak random elements, 3) The waveforms without fluctuation, and 4) The waveforms that not show any strong noisy waves.
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5. DISCUSSION

The obtained data from the three experiments showed tendencies of the four characteristics of the waveforms that were regraded to display the expression of the artifacts having a sense of being alive.

Firstly, the analysis results of all experiments showed the waveforms with some fluctuations that were detected as having the most significant expression of the sense of being alive compared to waveforms without any fluctuations \((P < 0.01)\). The word fluctuation was declared as “an irregular rising and falling of prices, numbers, rates, or etc.” (Oxford Advanced Learner’s Dictionary fifth edition, 1995).

Every type of waveform in this study that showed a fluctuation was found to have an influential circumstance for making the spectators observe the object having a sense of being alive. It was possible that this characteristic of the waveforms was related to making an irregular expression of the samples that might lead the participants to observe a sense of being alive. In general, a living thing is expressed in an irregular motion not in repetition; such as the variety of breathing rhythms in human body following its activity [19]. On the contrary, waveforms with regular rhythms without fluctuations, i.e., repeated patterns of events, changes, and/or activities were seen in the machine’s working procession that perform repetitive movements. Thus, this could be highly expressed as mechanical feelings.

Secondly, from the analysis, the expression of the artifacts in a smooth waveform was indicated as having a strong impact on the participant’s feeling of a sense of being alive. Participants rated the smooth waveform as being close as representing a sense of being alive, while the waveforms in other shapes; such as, triangular or square waveforms represented a mechanical feeling. According to the authors’ estimates, most waveforms in the triangular and square shape had a constant frequency between the fixed minimum and maximum values the same as the duration, which was set at the same minimum and maximum values. This characteristic might lead participants to consider the machine more than a living thing due to the machine being set to work under constant operation, such as the machines that were programmed to perform a repeated motion. Conversely, the participants might feel a sense of being alive from the smooth waveforms that had changeable values.

Thirdly, it was found that from an unexpected waveform, the rhythms of the waveforms’ actions could make participants have difficulty in predicting, which were also considered as providing a sense of being alive.

Anthropomorphic behavior is one example to express a sense being alive. It can be seen on some plants’ sensitivity as they grow towards the sun or those with digestive ability that trap insects with their leaf [15]. Thus why this waveform that consisted of strong random elements had a high tendency to make the participants feel a sense of being alive from the expression of the samples. On the contrary, a repetitive waveform, which was easy to remember and predict, was rated as expressing a mechanical feeling.

Fourthly, waveforms with unstable periods were discovered as having significance of expressing a sense of being alive greater than those waveforms with stable periods. An unstable waveform consisted of various waveform periods in different durations, while the stable waveform represented repetitive rhythms in the same duration. It was possible that the waveform with a stable period might refer to the rhythms of the machine that worked steadily. In contrast, waveforms with unstable periods might lead to the feelings of living things due to having independent expressions. As mentioned in the overview, independence could be defined as self-determinability, which would infer having the capability to make one’s own decisions and intelligence [12].

The results obviously show that the characteristics of the waveforms correlated with expressing a sense of being alive were opposite of the characteristics of waveforms correlated with expressing mechanical feeling. Waveforms that show a high tendency to express a sense of mechanical feeling are those linear stable waveforms without fluctuation.

The differentiated outcomes between each experiment could be specified as follows: 1) From the sound wave experiment and the changing form experiment, these had the same results of waveforms with a strong noisy wave. As such, this could be expressed as a sense of being alive more than those waveforms that did not have any strong, noisy or less strong, noisy waves. However, in the experiment of the flashing light, the rhythms of light with a strong, noisy wave could lead participants to observe the mechanical feeling, and 2) Although the waveforms with lower frequency rhythms were mostly selected as providing a sense of being alive in the experiment of flashing light rhythms, the results in the changing form experiment were different. The waveforms with a higher frequency were mostly chosen to represent a sense of being alive more in this phase.

6. CONCLUSION

This paper proposed to extract the factors related to the ability to express a sense of being alive of the artifacts. This study performed three experiments and developed the samples of the artifacts. The participants were asked to determine their feelings between the artifacts expressing a
sense of being alive or mechanical. From the results of the analysis, the authors found four characteristics of the waveforms that had a highly significant correlation with expressing a sense of being alive of the artifacts, which were 1) waveforms consisting of some fluctuations, 2) waveforms having a smooth shape, 3) waveforms having some random elements that were actions that were difficult to predict, and 4) waveforms comprising unstable periods. In this study, the literature review was used to design the simulations and reviewed the process of making the artifacts express a sense of being alive. However, the previous study only conducted a conceptual examination, which was difficult to implement as well as the received information did not produce the experimental data based on human feelings. The findings of this study could be useful for developing products expressing a sense of being alive in the future.

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