Emolleia – Wearable Kinetic Flower Display for Expressing Emotions

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Figure 1: The Emolleia Prototype. (a) shows the kinetic flower display worn by a user (the system is self-contained), (b) the interface over which the user can define the animated motions and colors, (c) depicts Emolleia in a social interaction context.

ABSTRACT

What we wear (our clothes and wearable accessories) can represent our mood at the moment. We developed *Emolleia* to explore how to make aesthetic wears more expressive to become a novel form of non-verbal communication to express our emotional feelings. *Emolleia* is an open wearable kinetic display in form of three 3D printed flowers that can dynamically open and close at different speeds. With our open-source platform, users can define their own animated motions. In this paper, we described the prototype design, hardware considerations, and user surveys (n=50) to evaluate the expressiveness of 8 pre-defined animated motions of *Emolleia*. Our initial results showed animated motions are feasible to communicate different emotional feelings especially at the valence and arousal dimensions. Based on the findings, we mapped eight pre-defined animated motions to the reported, user-perceived valence, arousal and dominance and discussed possible directions for future work.

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CCS CONCEPTS

• **Human-centered computing → Interface design prototyping**.

KEYWORDS

Wearable display, aesthetic wearables, emotion, interactive design, fashion

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1 INTRODUCTION

Under the epidemic situation of Covid-19, the necessity of wearing a face mask created an additional communication barrier for people to communicate or express their feelings. Face masks can soften a speaker's voice, conceal vocal tone, and hide facial expressions that relay essential non-verbal information[14].

What if our accessory could become a form of non-verbal communication to express our emotions and respond to our surroundings? How would clothing we pick up and wear every day would reflect our emotions instantly? Clothes and accessories are part of our self-expression, yet usually we can just change how we look and adjust it to our feelings a couple of times a day by putting on different clothing items [1, 7, 11, 16]. Non-verbal communication regulates relationships and can support or even replace verbal communications in many situations[24] .

In our research, we explore how to create expressive clothes and accessories that are able to instantaneously reflect our feelings. We work on integrating wearable computing in our clothes to dynamically show mood changes and represent how we feel in the moment.

In this paper, we present *Emolleia*, a wearable kinetic display in form of three 3D printed flowers that can dynamically open and close at different speeds. Users can define their own animated motions. The kinetic display is the result of several design iterations trying to capture the movements of flower ensembles. We want to explore whether this type of wearable accessory could be a novel form of non-verbal communication.

The contributions of this paper are as follows:

(1) We present the concept, design and prototype implementation of *Emolleia*, a kinetic display consisting of three flowers (the 3D model, components and software will be open-sourced). Moreover, the tools for building up the prototype will be accessible to the public.
(2) We conducted a user survey with 50 participants to elicit potential use and application cases.
(3) In the same session of user study with the same participants, we evaluated eight designed animated motions of *Emolleia* regarding their perceived emotional qualities using the Self-Assessment Manikin (SAM). Several animated motions show significant differences in perceived valence and arousal. [5]

2 RELATED WORK

There's a long line of research in wearable computing and in human-computer interaction field targeting the recognition, visualization, and evocation of emotions [15, 21, 23, 25, 27].

Researchers link garments, clothes and accessories to how we are perceiving ourselves and actively use these effects for communication and therapy [34]. There are several works using wearables to display and communicate emotional feedback in with kinetic using tactile sensations [10, 22].

Flowers are also often used as a way to express emotions. Bernhaupt et al. included flowers in a game as a feedback mechanism on how much the user is smiling while playing a game[3]. Urui et al. use flower displays for memorials to express mourning and remembrance [32].

Fashion makers and designers are also rethinking their trade and incorporating wearables in their designs [29]. There is an emerging area of 3D printed, computer generated fashion individualized for the user [30]. They utilize often the connections between shapes, forms and emotions [20]. Vasquez et al. present wearable, expressive accessories combining biodegradable materials with electronics [33]. However, there is little work on works that are dynamic and change while the user is wearing them.Most work in the wearable garment and accessories space focuses on utility and use cases (e.g. detecting wetness) [8, 17, 26, 31]. Vasquez et al. present wearable, expressive accessories combining biodegradable materials with electronics [33].

Dobbelstein et al. present a wearable olfactory display allowing users to receive multiple computer generated scents related to notifications, reminders or other kinds of digital data [6]. The Awe Goosebumps uses the inflatable silicone to externalize and amplify feelings of goosebumps [21].

We are inspired by the following research works and their vision closely. Berzowska et al. present the first prototypes of kinetic electronic garments focusing on self-expression [4]. Berglund et al. present a controllable, dynamic changing costume and extend this concept towards kinetic dynamics [2]. Jarusriboonchai et al. show a transforming dress that dynamically reveals and conceals areas of skin [12]. They also explore the design space of wearables for intimate communication [13]. The designed artifacts focus on wrist bands, earbuds etc. and are complimentary to the research presented here. We are not aware of any works presenting an open-source, wearable, kinetic display to express feelings.

3 DESIGN CONCEPT

Our initial intention was to design an emotive wearable computer to respond to surrounding people through non-verbal communication. We sought to explore more possibilities of expressing emotional feelings via wearable devices. We especially wanted to target the upper body and shoulder region, as they are visible in remote communications such as video conferences. Referring to related works and focus group discussions, we settled on a flower design.

The flower design was inspired by Diphylleia grayi, also known as the skeleton flower, has white petals which turn transparent when it makes contact with water [35]. The beautiful transformation and artistic outlook of the skeleton flower raised our interest. For underlining the translucency and flexibility of flower, Elastic 50A V1 was chosen as the petals' 3d printing material. The outlook of the garment was designed in a poetic way, three blooming transparent flowers were put on the base box, the size of the device is suitable enough for user to wear around the shoulder.

We conducted several pilot studies, first using one flower to see the animated motions. After expert feedback (2 designers, 4 wearable computing researchers) we found that the expressiveness of a single flower was limiting and decided to add 2 more to represent movement patterns.

The application ideas from experts ranged from signaling the willingness/reluctance for social interactions, over allowing interest matching in a party setting (flowers would represent the approximate match to the person you are closest to) to using the flowers as a socially acceptable shutter for a video camera (easy to see if its recording or not).

4 IMPLEMENTATION

The device was constructed by three main parts, flowers, servo motors case and a steel chain to fix the device on the body. The 3d printing flowers are fixed at the stem and consist of five petals with a diameter of 6 [cm]. We chose Elastic 50A resin as flower's material since the softness allows the prototype to bend over and reform motion freely, the special transparency of this material also matched our designed sketch.

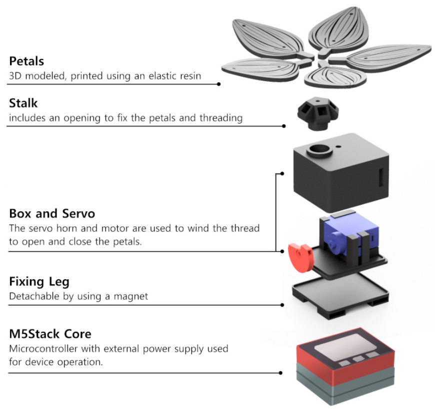

Figure 2: Overview of the assembly of *Emolleia*

We also provide users a software to let them monitor and customize the flower's motion and color of connected device (see Figure. 1). Users can set the motion triggered either by the groove sensor/buttons or interactive commands via serial communication such as Bluetooth and WiFi. The signal lines for each servo motor and RGB LED (NeoPixel compatible) are connected to the M5stack, and the power supply is 5[V] from an external power source such as a mobile battery.

5 USER STUDY

To explore potential use cases, self-expression possibilities and the general perception of the prototype, we conducted a user study.

The main purpose of this study was to measure how people perceive *Emolleia*'s motion in relation to emotional states and gain more insight into what people would like to use this prototype for and estimate prototype's social acceptability in different contexts. We refer to the PAD model which categorizes emotional states by three dimensional scales: pleasant/valence, arousal and dominance [19]. Lang et al. later develop a non-verbal pictorial self-assessment also known as SAM [18]. In our user study, we let subjects report their perceptions by SAM using a 5-point Likert scale (we are mostly interested in the valence and arousal dimensions, yet conducted the self-assessment according to related work) [9]. Besides, we included the Introversion-Extroversion Scale to investigate the potential feedback difference from participants with different various personality traits. The study was conducted according to the rules and regulations of Keio University with the approval of the Ethics Committee.

Participants. We collected survey answers from 50 participants aged from 21 to 37 (Male: 26, Female: 19, Diverse: 2, Prefer not to say: 3). Most of the participants (83%) came from Asian countries.

Study Protocol. The survey takes approximately 20 minutes to complete and consists of four parts: 1) demographic questionnaire 2) personality test by the Introversion-Extroversion Scale (I-E scale) [28] 3) the device utility study 4) the device animation study.

The I-E Scale assesses if a participant is more introverted or extroverted via a 5-point Likert scale (5 = Almost Always 4 = Frequently 3 = Occasionally 2 = Rarely 1 = Almost Never 0 = Doesn't Apply).

In the device utility study, we presented a 3-second video of one of our prototype's motions – one flower with simple open-up and close-up. We then asked questions about the general opinion, perceived function, and attitude towards this device. We asked participants who were willing to use the device to imagine the particular social contexts and under whose company they would like to wear it.

In the Animation study procedure, eight pre-recorded videos displaying different prototype on-body motions were shown to participants. The eight motions were: *a.* three flowers opening successively in 3 seconds, *b.*three flowers closing successively in 3 seconds,*c.* three flowers quivering simultaneously in 0.5 second,*d.* three flowers quivering simultaneously in 2 seconds, *e.*three flowers quivering randomly in 0.5 second, *f.* three flowers quivering randomly in 2 seconds, *g.* three flowers closing together in three seconds, *h.* three flowers opening together in three seconds. 3 Under each of the eight motions, participants were asked to rate the valence/arousal/dominance space of emotion via SAM where the participants choose one option from valence space (Pleasant, Pleased, Neutral, Unsatisfied, Unpleasant) arousal space (Excited, Wide-awake, Neutral, Dull, Calm) and dominance space (Dependent, Powerlessness, Neutral, Powerful, Independent) for rating three categories (pleasant/unpleasant and neutral) of motions [9].

5.1 Result

Based on the I-E scale answers from 50 participants, we discovered 27 participants were rated as average, 15 participants were rated as more introverted than usual or extremely introverted, and 8 participants were rated as more extroverted than usual or extremely extroverted.

69% of the participants showed a positive attitude towards wearing the device, one participant stated that "I love wearing wearable devices and hope this helps to track my mood or mind." Some participants expressed concern towards the size and suggested it might be inconvenient to wear and would like to decide whether to wear it after knowing more about the functions. For social acceptance, 62% of the participants reported it was acceptable to wear it at home. With the question of accompanying selection, 47% of the participants would wear it under friends' company.

To compare emotional interpretations about the prototype's eight animation, we operated repeated measures of ANOVA with Greenhouse-Geisser correction in SPSS to examine the scores' difference. There were statistically significant differences for valence ($F(4.84, 237.14) = 13.46$, $p < .001$) and arousal ($F(5.45, 267.11) = 38.28$, $p < .001$) across eight motion types. However, significant difference did not exist in the reported dominance ($F(4.40, 215.39) = 1.71$, $p =.14$). Figure.5 reports descriptive statistics of reported SAM scores about eight motions. Figure. 4 shows potential emotional state for each animation based on the average values of SAM referring to the prior work related to emotion dimensions [9].

Regarding to the potential scenarios of wearing *Emolleia*, answers mainly relates to self-expression (present wearer's mood,

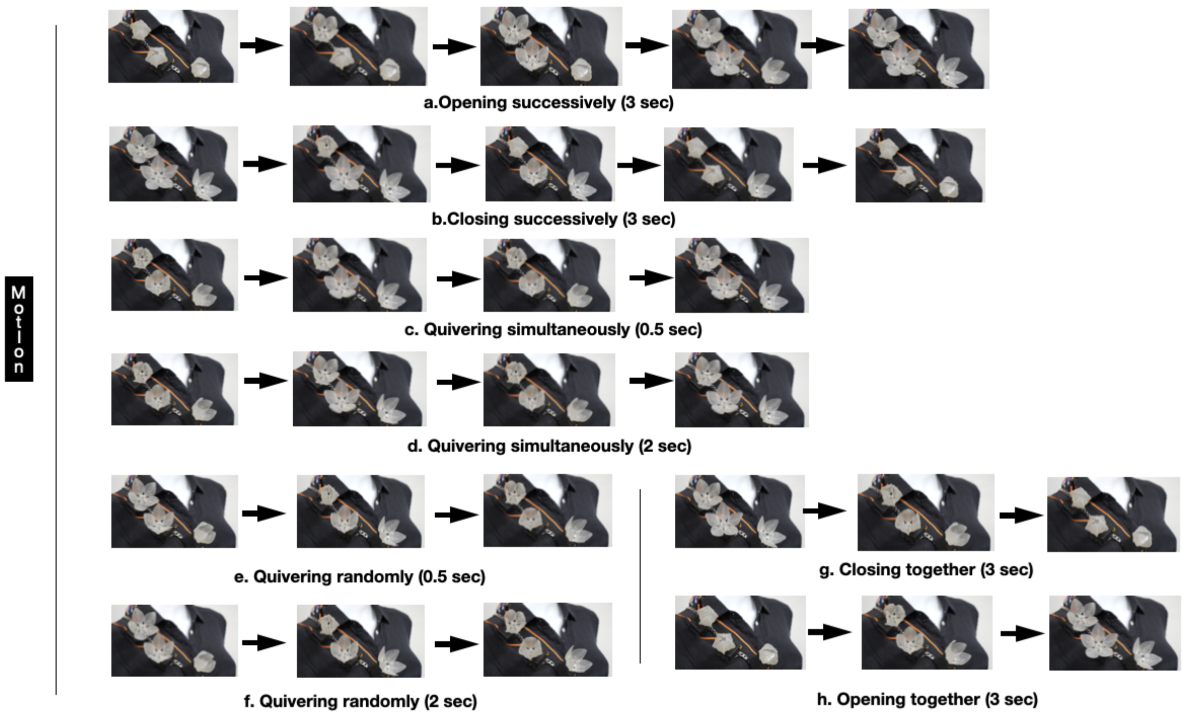

Figure 3: The eight *Emolleia* motions used in Animation Study, with 4 motion patterns performing in fast and slow two types of speed

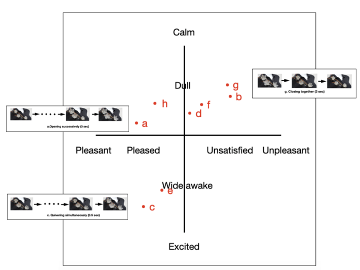

Figure 4: Eight Motions mapped to valence-arousal coordinate axes based on average SAM scores from survey results. Motion a,c,g seems to have more extreme performance than others, which could be used in the future work.

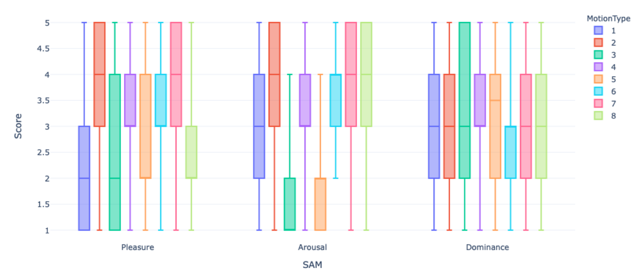

Figure 5: Eight motions' SAM score distribution, each motion is represented by one color.

feeling, mental status, emotional arousal, social attitude) and notification purpose (weather or noise display, hygrometer, message notice, daily water drinking reminder, plant hydration levels monitor, fire detection). One participant suggested that "It could be a really good device for children with special conditions, such as autism, vision or hearing impairment. The children can use the device to show their willingness to talk or the emotional status."

Among all the feedback, the most common usage scenario is to utilize *Emolleia* for self-expressing (*"can be an implicit inner world reflection to show others and connect with others with extimacy."*) (*"Assumes that emotion A and B are two poles apart: if opened, it could show people's emotion A ; If close, than shows people's emotion B."*), social interaction to build a deeper connection with others (*"I'd love to know how my family is doing through this. Especially grandparents, as they're wellness is my strong interest."*), some answers also mentioned the potential function to assist children with impairments to express their emotions or willingness to talk. (*"It could be a really good device for children with special conditions, such as autism, vision or hearing challenge. The children can use the device to show their willingness to talk or emotional status."*)

6 DISCUSSION

Overall, we found that there are different emotional interpretations among valence and arousal for eight animations. As for the feasibility to communicate different emotional states, the results of repeated measures ANOVA proves shows the potential of using eight motions to convey different emotions. By mapping the average SAM score of eight motions to the valence-arousal coordinate space, we further have more insights into matching animated motions with emotional feelings (see Figure. 4). For example, flowers opening motions (motion a & h) would be perceived as the representative of pleasant, satisfied and serene. Closing motions (motion b & g) tended to be interpreted as unsatisfied, frustrated and relaxed status. In general, the arousal of motion h and motion g where flowers open/close at the same time was slightly stronger than motion a and b where flowers open/close successively. The quivering motions with higher speed (motion c & e) were perceived as more pleasant and excited than those with a lower speed (motion d & f).

However, based on the results we received, there is no motion could be mapped in the fourth quadrant.

We wonder how would people with diverse personality traits perceive the eight pre-defined motions, and if social acceptance would have a significant difference among them. During the personality test, we received more than half of the results (54%) of personality traits that were rated average on the I/E scale. Therefore, it would be hard to compare introverts and extroverts.

7 FUTURE WORK

For future work, we will work on mapping eight motions with corresponding colors which could represent emotions for later iterations. Moreover, we plan to connect *Emolleia* with biometric sensors (e.g.: heart rate galvanic skin response) attached to users as the trigger for the motion change as the reveal of unconscious emotional status. A longer qualitative and quantitative study in real-life social conditions will be conducted as well, we will specify a group of users, for example, participants who mentioned autism, by letting them wear the device over the course for several days to learn how emotive wearable would assist them to understand their emotion and feelings.

We also plan to enlarge the sample size to collect more diverse feedback in terms of personality traits.

We developed a software/platform for users to define their own animations to express their emotions, for further development, we would consider running some workshops where designers could freely generate motion patterns, then test whether the users would distinguish them.

Figure 6: *Emolleia* with color mapping.

8 CONCLUSION

In this paper, we introduced our novel kinetic wearable device *Emolleia* which is able to perform eight pre-defined animated motions. We explored how wearable accessories and clothes can reflect our feelings and become new form of non-verbal communication. We conducted a user study with 50 participants to elicit potential usages and social scenarios. We also collected their perceptions about eight animated motions by SAM scale to help us further improve our motion design. Feedback from the participants proved the feasibility of our concept about communicating emotional feelings via *Emolleia*.

Although using wearable computers to enhance social interaction is not new in HCI field, our study still brought up new sight on exploring how people would define prototype animation with emotion, and how well wearable device would be accepted in the daily social context. Furthermore, it is an attempt on building a bridge between design, engineering, art and science. Wearable computers can be fashionable to wear, and accessory is capable of expressing emotions.

According to the answers we collected from the user study, participants raised some concerns towards *Emolleia*'s size and wearing position, we would like to conduct few tests and find the most suitable place for *Emolleia* to be presented.

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