Emotion Bouquet: Exploring Emotion Physicalization through Soft Robotics

Hanna Danilishyna*
Bauhaus-Universität Weimar
Germany
hanna.danilishyna@uni-weimar.de

Alisa Popp*
Bauhaus-Universität Weimar
Germany
alisa.popp@uni-weimar.de

Rosa van Koningsbruggen
Bauhaus-Universität Weimar
Germany
rosa.donna.van.koningsbruggen@uni-weimar.de

Eva Hornecker
Bauhaus-Universität Weimar
Germany
eva.hornecker@uni-weimar.de

Figure 1: Four flowers, representing four emotions. From left to right: (1) anger, (2) calm, (3) happy, and (4) sad.

Abstract

It has become increasingly possible to track and represent our emotions to get better understanding of them. However, whereas our emotions are ephemeral and fluctuate, common representations of emotions look true, permanent, and scientific. To explore how we can represent emotions in a way that is closer to how we feel and experience them, Emotion Bouquet was created. Emotion Bouquet consist of four pneumatic flowers that represent the four emotions of anger, sadness, calmness, and happiness through the shape, color, and movement of each flower. Pneumatics were used to created breathing patterns that replicate the our breathing during the respective emotions. For the color mappings, we relied on existing literature. Emotion Bouquet was deployed during a two-day exhibition. With this work, we aim to show the potential of soft robotic, physical data representations for the representation of emotions.

CCS Concepts

• **Human-centered computing** → *Visualization techniques.*

Keywords

inflatables, pneumatics, data physicalization

*These authors contributed equally to this work.

Published by the Gesellschaft für Informatik e.V.: Mensch und Computer 2024 – Workshopband, 01.-04. September 2024, Karlsruhe, Germany

https://doi.org/10.18420/muc2024-mci-demo-371

1 Introduction and Background

Emotions have a significant impact on our choices, relationships, and general wellbeing. At the same time, it can be difficult to (fully) understand or even listen to our emotions in our daily lives [6]. To help us better understand our emotions, there has been an uptake in technological 'solutions', such as mood trackers [3]. These often represent our emotion data in pre-defined 2D visualisations that look clean, rational, and neutral [4, 7, 17]. A far cry from how we experience our emotions [18].

To explore a more embodied and live-like representation of our emotion data, we created a *data physicalization*: a physical object that represents data [12]. Whereas data visualisation tends to aim at accuracy and efficiency [10], data physicalization has a different set of strengths and weaknesses [25]. As there are currently no rules for encoding and representing data in physicalization, each encounter requires the viewer/user to explore what the data are and what they mean—thus, fostering reflection [21]. This creates space beyond rational analysis (which we tend to do with visualisations [24]), with room for empathy, and affective and visceral responses [19, 28]. Moreover, by using shape-change, physicalizations can embody the dynamic nature of data and foster a feeling of wonder [19].

However, most dynamic physicalizations rely on motorised, rigid approaches, rather than soft robotics, cf. [5]. Considering that soft robotics offer affective and hedonic qualities [9, 14, 26] it seems

fruitful to use them for data physicalization, as physicalizations also benefit from affective qualities [21, 25, 28].

Because of physicalization's and soft robotic's emotive side, this work explores the physical representation of emotions, offering a novel way to experience them. Extending the visual connection of emotion and color, shape and movement were mapped to four emotions (happiness, anger, calmness, and sadness)—creating a tangible and lively representation [19]. To do this, four inflatable flowers were created that represent the four emotions. The installation of the flowers was deployed at a two-day university exhibition.

With this installation, we explore the potential of physicalizing emotions using soft robotics, and seek interaction and reflection. Based on this work, we see potential in using soft dynamic physicalizations to represent 'subjective' (or difficult to quantify [23]) and ephemeral data.

2 The Design

To go beyond common representations of emotions, and to acknowledge emotions' expressive and dynamic behaviour, we created a data physicalization called *"Emotion Bouquet"* using pneumatics. As emotions are fluid –they can quickly change from one emotion to another or multiple emotions can be experienced at the same time– we believe that static representations of emotions do not properly represent these fluctuations of our inner lives. Therefore, we specifically focus on a dynamic physicalization that uses movement and color change to represent fluctuations in the data.

Previous work has found that physicalizations benefit from metaphors to ground the data, as metaphors provide context and a narrative arc [23]. Therefore, we chose the metaphors of flowers and decay. Like a flower, human emotions are ephemeral, they come and go. Being aware of this, one can find beauty in every emotion, as suggested by the Japanese philosophy of Wabi-Sabi [16], which promotes awareness of the transience of everything in life.

For Emotion Bouquet, we focused on representing four emotions: happiness, calmness, sadness, and anger. These emotions were chosen for the expressive behavior that could be used to represent them. For example, if someone is angry, there is a fastness of breath, their face might turn red, and their heart rate goes up.

To create expressive behaviors for the emotions in our physicalization, we used color, shape, and movement to represent these emotions. Beneath, we explain the mappings and the reason for selecting them, as well as our technical set-up.

2.1 Color and Brightness

Colors are often associated to emotions [15] and commonly used in mood tracking / representing technologies [3]. Despite color's popularity for representing emotions, there is no universal linkage between the two—colors having different meanings in different cultures [1, 11]. As our demo was developed and exhibited in Germany, we decided to use color associations commonly used in this part of the world. Happiness was represented as yellow, anger as red, calmness as green, and sadness as blue. These mappings follow the work of Kaya and Epps [15].

The color of each flower was created using WS2812 LED strips beneath each flower. The brightness of each flower represents the intensity of the emotion (full brightness is high intensity, low brightness is low intensity).

2.2 Shape

Research has found that there is a visual link between shape and emotions [20]: objects with round edges are associated with positive valence, whereas sharp and angled edges relate to negative valence. Furthermore, smooth surfaces and edges are considered low arousal, and edges and surfaces with visual variations (e.g., extrusions) as high arousal. These links between shape and emotions informed our designs for the flower petals. Happiness and calmness are presented by big, round shapes, to express their positive valence and low arousal. On the other hand, sadness and anger are represented by smaller and edgier petals, showing their negative valence and high arousal.

For consistency in visual density, each flower is composed of six petals, three inner and three outer ones. The petals are made out of translucent TPU, allowing light to pass through easily. Flowers were hand-crafted using the wire-shaping approach described by Gholke et al. [8], where a pattern is constructed out of metal wire. For each emotion / flower, a unique pattern was constructed. The pattern is then placed on top of the TPU under a heat press, welding the material into an inflatable balloon. We refer to Gholke et al. for a detailed description of the welding procedure [8].

2.3 Movement

Besides color and shape, the behavior of each flower contributes to the representation of the emotion. From dance and other art forms, it is known that movements can represent emotions [22]. The expressivity of movements has been researched and used in HCI, for example, for soft robotics [13].

One of the strongest movement qualities of pneumatics are movements that remind us of breathing patterns—based on the amount of air that is in the inflatable, the inflatable either in- or deflates, replicating movements made by the inflation of lungs. As there is a link between breathing and emotion as well [2] –with emotions such as anger making us breathe faster, whereas calmness is characterized by slow breathing– each emotion was mapped to a breathing pattern to map their level of arousal.

Anger is represented through quick, intense breathing, created by a fast and strong inflation of the petals. Sadness is represented through slow breathing, where the petals are slowly inflated, below the full capacity of the inflatable petals. Thus, never showing the 'full potential' of the flower—the flower is never in bloom, always looking a bit empty and sad. For happiness, a quick breathing pattern, where the petals are fully inflated was made to show a pattern of excitement. Lastly, calmness is represented by moderately inflating the petals (they are not fully inflated, but also do not look empty, as with sadness) and slow breathing by slowly in- and deflating the petals.

2.4 Technical Setup

The overall design consists of two parts: the flowers on top of the box (Figure 2, left) and the mechanics underneath that control the inflatable flowers (Figure 2, right).

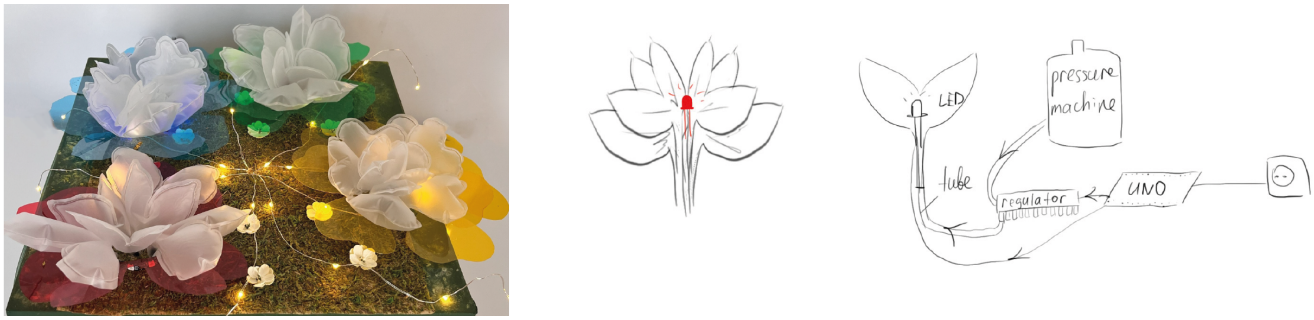

Figure 2: Left: The physicalization of the four emotions. Right: A drawing of the control mechanism of the physicalization.

For the mechanics, we relied on the same control mechanism as Waldschütz et al. [27], called *"pneuCNTRL"*. The individual petals (twenty-four in total) are connected by flexible tubes to an electromechanical valve, which in turn is connected to an air compressor machine. "pneuCNTRL" is Arduino controlled, allowing us to use it for controlling the levels of in- and deflation needed to create the desired movement patterns for the emotion flowers. Specifically, we used "pneuCNTRL" to create the following basic breathing algorithm for the emotions: (1) time for letting air in, (2) a short delay at the peak (which reflects the short break at the end of each breath), (3) time to fade and release air, (4) short break. This basic pattern is based on natural breath and was fine-tuned for each emotion, by determining the peak value (the maximum inflated value) of each emotion, and timing the breaks and speed of in-/deflation.

The LED strips for the color and brightness of each flower were also controlled by Arduino. Although the overall brightness represented the intensity of the emotion, for consistency and showing the futile nature of emotions, the brightness followed the same breathing algorithm to fade in and out.

3 Case Study/Demo

Emotion Bouquet was exhibited during a fair of the [redacted] university's projects. For exhibition purposes, an imaginative emotion data set was developed, that covered the four emotions to show the full possibilities of Emotion Bouquet.

During the fair, we asked for people's feedback and reactions to the artefact. Eight people interacted with the physicalization. Their overall response was positive. We found that the installation caught the attention of these visitors as they entered the exhibition space, especially when it was darker during the evening, as the light was more illuminating. From the conversations that took place about the artefact, we noted excitement and interest about it, and some reported feelings of immersion. However, explanations were needed to fully understand it. The physicalization can be made more self-explanatory, if the data input stems from the viewer/user, so that the physicalization's behavior is feedback to their data.

4 Conclusion

To better embody how we experience emotions and how these can be represented, we created Emotion Bouquet: a pneumatic, dynamic data physicalization. Emotion Bouquet consists of four inflatable flowers, whose shape, color, and breathing patterns represent the four emotions of happiness, sadness, calmness, and anger. Emotion Bouquet was presented at an exhibition, where we sought visitor's feedback. Initial responses revealed that Emotion Bouquet can elicit hedonic responses. This work aims to highlight the potential of soft robotics in emotion physicalization. To this end, the installation should be extended to allow for user input and thus explore different use cases such as group sentiment or chronological representation of one's own emotions.

Acknowledgements

References

[1] Francis M Adams and Charles E Osgood. 1973. A cross-cultural study of the affective meanings of color. *J. Cross. Cult. Psychol.* 4, 2 (June 1973), 135–156.

[2] Frans A. Boiten. 1998. The effects of emotional behaviour on components of the respiratory cycle. *Biological Psychology* 49, 1 (Sept. 1998), 495–504. https://doi.org/10.1016\protect\T1\textsection0301-0511(98)00025-8

[3] Clara Caldeira, Yu Chen, Lesley Chan, Vivian Pham, Yunan Chen, and Kai Zheng. 2017. Mobile apps for mood tracking: an analysis of features and user reviews. *AMIA Annual Symposium Proceedings* 14, 1 (April 2017), 495–504.

[4] Catherine D'Ignazio and Lauren F. Klein. 2020. *Data Feminism.* The MIT Press, Cambridge, Massachusetts, USA. https://mitpress.mit.edu/books/data-feminism

[5] Hessam Djavaherpour, Faramarz Samavati, Ali Mahdavi-Amiri, Fatemeh Yazdanbakhsh, Samuel Huron, Richard Levy, Yvonne Jansen, and Lora Oehlberg. 2021. Data to physicalization: A survey of the physical rendering process. (Feb. 2021). arXiv:2102.11175 [cs.GR]

[6] Paul Gilbert. 2003. *Mindful Compassion.* New Harbinger Publications, Oakland, CA.

[7] Lisa Gitelman (Ed.). 2019. *"raw data" is an oxymoron.* MIT Press, London, England.

[8] Kristian Gohlke, Hannes Waldschütz, and Eva Hornecker. 2023. WireShape - A Hybrid Prototyping Process for Fast & Reliable Manufacturing of Inflatable Interface Props with CNC-Fabricated Heat–Sealing Tools. In *Proceedings of the 8th ACM Symposium on Computational Fabrication* (New York City, NY, USA) *(SCF '23).* Association for Computing Machinery, New York, NY, USA, Article 7, 8 pages. https://doi.org/10.1145/3623263.3623363

[9] Yuhan Hu and Guy Hoffman. 2023. What Can a Robot's Skin Be? Designing Texture-Changing Skin for Human–Robot Social Interaction. *J. Hum.-Robot Interact.* 12, 2, Article 26 (apr 2023), 19 pages. https://doi.org/10.1145/3532772

[10] Jessica Hullman and Nick Diakopoulos. 2011. Visualization Rhetoric: Framing Effects in Narrative Visualization. *IEEE Transactions on Visualization and Computer Graphics* 17, 12 (2011), 2231–2240. https://doi.org/10.1109/TVCG.2011.255

[11] Ralph B Hupka, Zbigniew Zaleski, Jurgen Otto, Lucy Reidl, and Nadia V Tarabrina. 1997. The colors of anger, envy, fear, and jealousy. *J. Cross. Cult. Psychol.* 28, 2 (March 1997), 156–171.

[12] Yvonne Jansen, Pierre Dragicevic, Petra Isenberg, Jason Alexander, Abhijit Karnik, Johan Kildal, Sriram Subramanian, and Kasper Hornbæk. 2015. Opportunities and Challenges for Data Physicalization. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15).* Association for Computing Machinery, New York, NY, USA, 3227–3236. https://doi.org/10.1145/2702123.2702180 event-place: Seoul, Republic of Korea.

[13] Jonas Jørgensen. 2017. Leveraging morphological computation for expressive movement generation in a soft robotic artwork. In *Proceedings of the 4th International Conference on Movement Computing* (London, United Kingdom) *(MOCO '17).*

Association for Computing Machinery, New York, NY, USA, Article 20, 4 pages. https://doi.org/10.1145/3077981.3078029

[14] Jonas Jørgensen. 2023. Towards a Soft Science of Soft Robots. A Call for a Place for Aesthetics in Soft Robotics Research. *J. Hum.-Robot Interact.* 12, 2, Article 15 (mar 2023), 11 pages. https://doi.org/10.1145/3533681

[15] Naz Kaya and Helen Epps. 2004. Relationship between color and emotion: A study of college students. *College Student Journal* 38, 3 (2004), 396–405.

[16] Beth Kempton. 2019. *Wabi Sabi.* Little, Brown Book Group.

[17] Helen Kennedy, Rosemary Lucy Hill, Giorgia Aiello, and William Allen. 2016. The work that visualisation conventions do. *Inf. Commun. Soc.* 19, 6 (June 2016), 715–735.

[18] Dan Lockton, Delanie Ricketts, Shruti Aditya Chowdhury, and Chang Hee Lee. 2017. Exploring Qualitative Displays and Interfaces. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (Denver Colorado USA). ACM, New York, NY, USA.

[19] Deborah Lupton. 2017. Feeling your data: Touch and making sense of personal digital data. *New Media & Society* 19, 10 (July 2017), 1599–1614.

[20] Edward Melcer and Katherine Isbister. 2016. Motion, Emotion, and Form: Exploring Affective Dimensions of Shape. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI EA '16)*. Association for Computing Machinery, New York, NY, USA, 1430–1437. https://doi.org/10.1145/2851581.2892361

[21] Dietmar Offenhuber. 2020. What we talk about when we talk about data physicality. *IEEE Computer Graphics and Applications* 40, 6 (June 2020), 25–37. https://doi.org/10.1109/MCG.2020.3024146

[22] Maxine Sheets-Johnstone. 1999. Emotion and movement. A beginning empirical-phenomenological analysis of their relationship. *Journal of Consciousness Studies* 6, 11-12 (1999), 259–277.

[23] Rosa Van Koningsbruggen, Luke Haliburton, Beat Rossmy, Ceenu George, Eva Hornecker, and Bart Hengeveld. 2024. Metaphors and 'Tacit' Data: the Role of Metaphors in Data and Physical Data Representations. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Cork, Ireland) *(TEI '24)*. Association for Computing Machinery, New York, NY, USA, Article 7, 17 pages. https://doi.org/10.1145/3623509.3633355

[24] Rosa van Koningsbruggen and Eva Hornecker. 2021. "It's Just a Graph" – The Effect of Post-Hoc Rationalisation on InfoVis Evaluation. In *Proceedings of the 13th Conference on Creativity and Cognition* (Virtual Event, Italy) *(C&C '21)*. Association for Computing Machinery, New York, NY, USA, Article 45, 10 pages. https://doi.org/10.1145/3450741.3465257

[25] Rosa van Koningsbruggen, Hannes Waldschütz, and Eva Hornecker. 2022. What is Data? - Exploring the Meaning of Data in Data Physicalisation Teaching. In *Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Daejeon, Republic of Korea) *(TEI '22)*. Association for Computing Machinery, New York, NY, USA, Article 13, 21 pages. https://doi.org/10.1145/3490149.3501319

[26] Joachim von Zitzewitz, Patrick M Boesch, Peter Wolf, and Robert Riener. 2013. Quantifying the human likeness of a humanoid robot. *Int. J. Soc. Robot.* 5, 2 (April 2013), 263–276.

[27] Hannes Waldschütz, Rosa Van Koningsbruggen, and Eva Hornecker. 2024. pneuCNTRL: a Pneumatic Control System for User Studies on Dynamic, Haptic Inflatables. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction* (<conf-loc>, <city>Cork</city>, <country>Ireland</country>, </conf-loc>) *(TEI '24)*. Association for Computing Machinery, New York, NY, USA, Article 82, 5 pages. https://doi.org/10.1145/3623509.3635263

[28] Yun Wang, Adrien Segal, Roberta Klatzky, Daniel F. Keefe, Petra Isenberg, Jorn Hurtienne, Eva Hornecker, Tim Dwyer, Stephen Barrass, and Theresa-Marie Rhyne. 2019. An Emotional Response to the Value of Visualization. *IEEE Computer Graphics and Applications* 39, 5 (Sept. 2019), 8–17. https://doi.org/10.1109/MCG.2019.2923483