EchoSense: Frontal Haptic Navigation in VR towards Biomimetic Empathy

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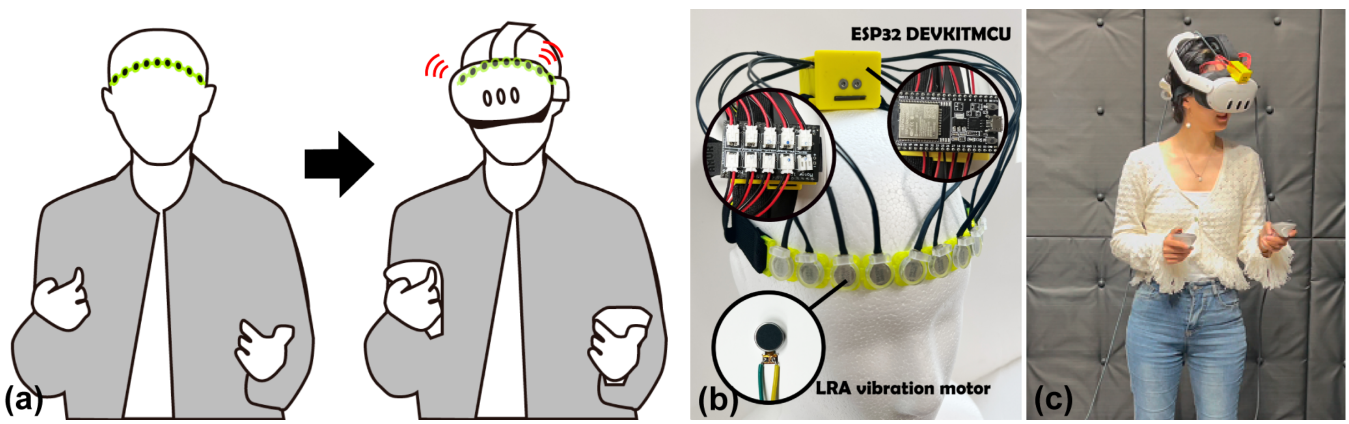

Figure 1: (a) The forehead-mounted wearable is integrated into the inner surface of a VR headset. (b) Exploded view of the device, comprising an ESP32 microcontroller and nine LRA vibration motors, connected via a 3D-printed flexible substrate. (c) A user wearing and interacting with the system during operation.

Abstract

We present EchoSense, a forehead-mounted vibrotactile wearable system that simulates dolphin echolocation in virtual reality (VR). Drawing from biomimetic principles and multisensory interaction, the system translates spatial and directional sonar information into tactile feedback on the user's forehead. Integrated into a VR headset, EchoSense enables users to perceive the position and distance of underwater objects via vibration patterns that reflect the direction and simulated time-of-flight (ToF) of sonar pulses. Through an immersive dolphin embodiment experience across two scenarios (pristine and polluted oceans), users navigate, forage, and connect with other dolphins using only their head and minimal controller input. Our

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system highlights how non-visual, animal-inspired interfaces can support embodied spatial awareness, empathic interaction, and environmental reflection in XR.

CCS Concepts

• **Human-centered computing → Haptic devices**; Virtual reality; *Empathy*.

Keywords

haptics, forehead interface, multi-sensory, virtual reality, empathy

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1 Introduction

Animals such as dolphins and bats have evolved sophisticated echolocation systems that allow them to navigate and detect objects through sound [14, 18]. These animals emit high-frequency pulses and interpret the returning echoes to detect the location, shape, and movement of nearby objects, which enables them to navigate freely even in environments where vision is limited [3]. Dolphins, for example, posess a biological system called echolocation or bio sonar [24], that can emit ultrasonic clicks through a specialized forehead structure called the melon and receive returning echoes via receptors in the lower jaw. These acoustic signals are integrated with visual input and processed in the brain to determine the direction, distance, and even internal structure of target objects (as Fig.2).

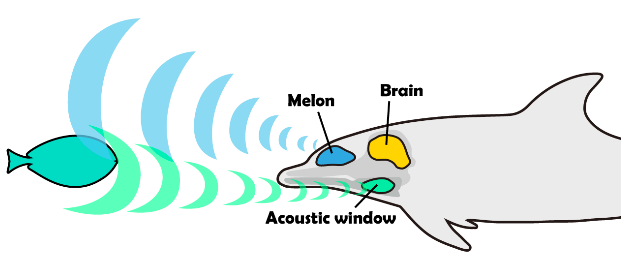

Figure 2: Dolphins emit ultrasonic clicks through a specialized forehead organ called the melon, which focuses sound into a directional beam. Reflected echoes from surrounding objects are received via the lower jaw and processed by the brain to determine the direction, distance, and shape of the object, enabling precise spatial perception through echolocation.

Drawing on such biological systems, HCI researchers have increasingly looked toward biomimetic interaction design to inform novel human-computer interfaces to enhance presence, embodiment, and user engagement [17, 30]. By simulating real-world perception, such systems have not only enriched cognitive and emotional engagement but also been explored to support affective communication and embodied experience, particularly through integrated multisensory approaches [11, 13]. Among these modalities, haptic feedback plays a critical role in bridging the gap between virtual stimuli and physical sensation. Prior work has explored a range of haptic strategies, including vibrotactile cues, thermal signals, and force feedback to improve spatial awareness, object manipulation, and affective communication in VR environments [19, 21, 27].

Inspired by dolphin echolocation, this study investigates a multisensory wearable device embedded in the forehead area of a VR headset. The system simulates sonar-like perception through directional vibrotactile feedback. We explore how forehead-centered haptic sonar can support spatial object localization, foster empathic engagement in extended reality (XR) environments, and enable non-visual navigation, environmental awareness, and emotional resonance in immersive experiences.

2 Related Work

Since its emergence in the mid-20th century [29], biomimetics has significantly influenced fields such as robotics, computer science, and bioengineering [5, 17]. As an interdisciplinary domain, it draws on natural systems to solve complex engineering problems through two major approaches: biology-to-design (bottom-up) and challenge-to-biology (top-down) [23]. Innovations span form, function, and ecology, with applications in sustainability, architecture, robotics, and interaction design. However, due to physical and technical constraints, it remains challenging to realize biomimetic systems.

In HCI, empathy has been studied through both perceptual modeling (inferring emotional states) and expressive modeling (system responses) [16, 19, 28]. Systems like Kismet [8] and EmoReact [25] replicate empathic behaviors using facial, vocal, and physiological cues. Some draw inspiration from mirror neuron mechanisms to simulate affective resonance [30]. Wearable and VR-based systems further support embodied empathic interaction. Tactile systems such as EmpaTalk and HapticEmpathy deliver emotional cues via vibration or pulse feedback [19, 21], while VR experiences enable perspective-taking and embodied empathy through avatar embodiment and immersive design [4, 7]. Recent work has used VR to promote empathy toward animals by simulating their perspective in immersive contexts [9, 26]. Meanwhile, biomimetic haptic feedback remains underutilized as a channel to express or elicit empathy. This limits the capacity of current systems to enable multimodal empathic interaction, especially where bodily sensation and emotional resonance are essential.

While most haptic hardware focuses on the hands and arms, alternative systems have been developed for other body parts, including the torso (e.g., vests, belts), lower limbs, and the head. Among these, head-mounted haptic systems remain less explored [1]. Such systems typically take the form of helmets or hat-like wearables and provide vibrotactile [2], thermal [27], or pressure-based feedback [15], varying in terms of actuator placement and the type of force delivered. Functionally, head-mounted haptics have been applied to support spatial perception and navigation [2, 6, 20, 22], immersive XR experiences [27, 31], and accessibility tools for deaf or hard-of-hearing users via spatial vibrotactile signals [10]. Despite the capacity of human head for spatial discrimination, the forehead remains underexplored as a haptic interface. Prior work suggests its potential to convey rich vibrotactile patterns [10, 12], yet applications for affective modulation, such as emotion communication or stress signaling, are still limited. Based on the above research, we investigate the forehead as an active haptic interface, with a particular focus on how forehead-based vibrotactile feedback influences users' emotions, interactions, and environmental awareness.

3 Implementation and Design

Dolphins' echolocation process integrates precise time-of-flight (ToF) analysis with spatial acoustic patterns, allowing for non-visual navigation and object recognition, even in low-visibility environments. Following the biology-to-design (bottom-up) biomimetic approach [23], we draw on this natural system not by replicating its auditory modality, but by translating its perceptual mechanism into an alternative sensory pathway, touch. Specifically, we map spatial information (direction and distance) into forehead-based vibrotactile feedback, leveraging the forehead's high tactile sensitivity and its alignment with the user's egocentric field of view.

This design choice is motivated by several factors:

- Human auditory spatial localization is limited in precision, particularly for front-facing or near-field sources, and may be easily masked in noisy or visually complex VR environments.
- The forehead has been identified as one of the most sensitive regions of the human body for tactile feedback[12], making it an ideal site for delivering fine-grained vibrotactile information without obstructing vision or impeding interaction.
- Integrating feedback into the head-mounted display (HMD) allows for seamless embodiment and minimal hardware intrusion, supporting naturalistic and immersive use cases.

Rather than reproducing the experience of hearing echoes, our system enables users to receive spatial cues through directional vibration, simulating a sonar-like interaction model through controlled tactile stimulation. In doing so, we reimagine echolocation not as an auditory phenomenon but as a multisensory interface that supports spatial awareness, navigation, and empathic embodiment in virtual environments.

3.1 Wearable Device

We developed a lightweight, forehead-mounted haptic interface that delivers direction-based and distance-based tactile feedback. The device is embedded into the inner surface of a standard VR headset, allowing for direct skin contact while maintaining user comfort. Its housing is 3D-printed using flexible, skin-safe materials to accommodate different forehead shapes (as Fig.1(b)).

The hardware system consists of an ESP32 DEVKIT microcontroller connected to nine linear resonant actuators (LRAs) arranged horizontally across the forehead. These actuators correspond to nine 20° sectors spanning the user's 180° forward-facing field of view. Each motor is independently addressable, allowing for precise control over vibration intensity and timing.

The actuators operate at approximately 150 Hz, with each activation lasting 1500 ms and following a linear decay profile to produce a smooth tactile fade-out. When multiple actuators are triggered simultaneously (e.g., for wider targets), an exponential temporal decay is applied from the center outward, enhancing directional salience and reinforcing the perceived location of the stimulus.

3.2 VR Experience

In designing the VR experience, our goal was not only to allow users to engage with a dolphin's echolocation system through multisensory interaction, but also to foster empathy and awareness of marine life by embodying its survival challenges. To achieve this, we created four interactive events across two distinct environmental scenarios based on the Unity3D[1] game engine, aimed at highlighting the impact of ocean pollution and deepening users' emotional connection with aquatic ecosystems.

Here, we describe our interactive events:

Movement and direction control. To maximize the sense of embodiment, we limited user input to only forward and backwards movements via the joystick on the right-hand controller. Users control the dolphin's locomotion in the virtual environment by pushing the joystick forward or backwards. Rotational control on both the horizontal and vertical axes is handled entirely through the orientation of the VR headset, allowing for natural head-driven navigation. To enhance realism, the user's movement is synchronized with a dolphin swimming animation, reinforcing the sensation of inhabiting a dolphin's body.

Echolocation system. Users trigger the sonar emission by pressing the toggle button on the left-hand controller. Upon activation, a red visual sonar wave is emitted across the virtual seafloor, halting and returning upon collision with environmental obstacles. To enhance immersion and biological realism, a synchronized dolphin "click" sound is played each time the sonar pulse is emitted, simulating the vocalization dolphins produce during real-world echolocation. The system divides the user's 180° forward-facing field of view into

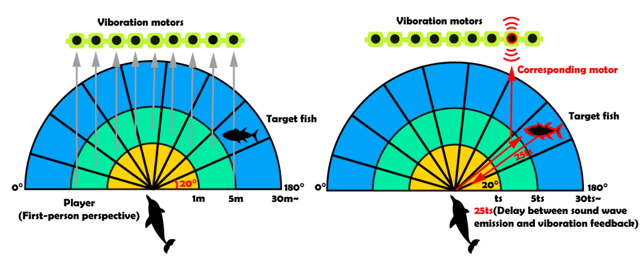

Figure 3: The 180° horizontal field in front of the user is divided into nine 20° sectors, each mapped to a specific vibrotactile actuator on the forehead. When a target fish appears within a sector, the corresponding actuator delivers a delayed vibration to simulate sonar-based distance feedback.

nine horizontal segments (each covering 20°), with each segment mapped to a corresponding actuator in the forehead-mounted vibrotactile array. After each scan, the system automatically identifies

[1] https://unity.com/

the nearest fish within view, highlights it in red (as Fig.4(c)), and activates the corresponding forehead motor with a time delay based on the simulated ToF of the sonar pulse. To help users differentiate between types of fish (such as food, predators, or companions), we implemented distinct vibrotactile patterns using one, three, or five adjacent actuators to represent different target sizes and categories.

Predation. Once the echolocation system highlights a target fish, the user can navigate the dolphin toward it. Upon contact, a swallowing sound is played and a predation event is triggered, increasing the user's survival score.

Searching for companions. At the midpoint of the experience, the user hears a calling sound from a companion dolphin, prompting a search task. During this phase, the echolocation system prioritizes detecting the companion's location. Once the companion appears within the user's field of view and is successfully identified by the system, it is highlighted in blue(as Fig.4(b)). The user must then navigate toward and make contact with the companion, which triggers a heart-shaped visual interface indicating successful connection.

Avoiding predators. The user must avoid approaching predators to prevent death. The echolocation system assists by identifying the predator's location; when a predator enters the detection range, it is highlighted in red, and the user receives corresponding vibrotactile feedback to signal danger.

We then describe the two scenes:

Scene 1 "the Ocean in Memory" The "Ocean of Memory" scene

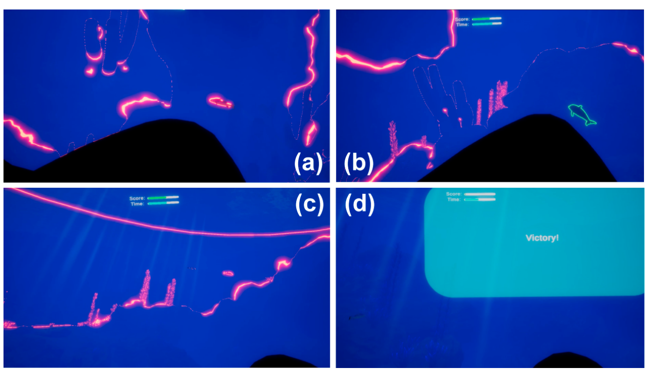

Figure 4: (a) A visualization of dolphin echolocation in a pristine marine environment. (b) The dolphin locates a companion using its biosonar system. (c) The echolocation system automatically highlights the nearest food target within the field of view. (d) The player wins by successfully capturing a sufficient number of fish.

depicts a pristine underwater world bathed in sunlight. Coral reefs and swaying seagrass move gently with the current, creating a serene and vibrant marine environment. In this setting, the water is remarkably clear, allowing for excellent visibility. Dolphins can navigate with ease, and fish are readily visible to the naked eye, even without activating the echolocation system. This high-visibility environment offers a stark contrast to the polluted scenario, emphasizing the beauty and navigability of an unspoiled ocean.

Scene 2 "the Polluted Ocean" In contrast, the "Polluted Ocean" scene presents a dark and deteriorated underwater environment.

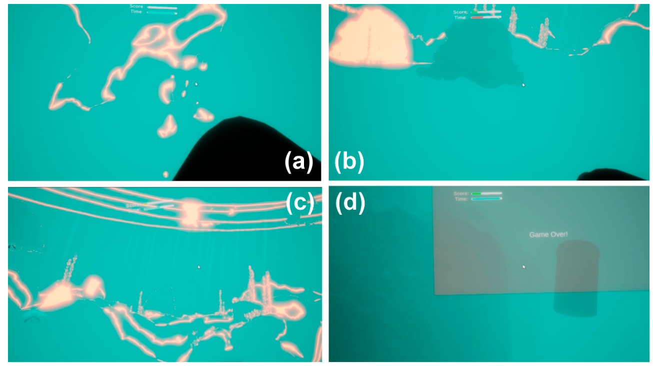

Figure 5: (a) A visualization of dolphin echolocation in a polluted marine environment with reduced visual clarity. (b) In the polluted ocean, sonar feedback may be disrupted, causing the dolphin to mistakenly identify debris as food. (c) It becomes increasingly difficult for the dolphin to locate actual food sources. (d) Failure to capture sufficient food within the allotted time results in the dolphin's death.

The water appears greenish and is filled with suspended particles and debris, significantly reducing visibility. Coral reefs seem bleached or fragmented, while plastic waste and unidentified pollutants drift among the remnants of seagrass. In such conditions, visual navigation becomes challenging, as fish are no longer easily visible to the naked eye. The dolphin must rely heavily on its echolocation system to detect nearby objects. However, the sonar feedback is frequently disrupted by non-biological obstacles such as plastic bags and bottles, which may be mistakenly identified as prey (as Fig.5(b) and (c)). This degraded environment is designed to evoke a sense of urgency and empathy, highlighting the impact of marine pollution on both aquatic life and sensory-based navigation.

4 Conclusion and Future Works

EchoSense explores how forehead-mounted vibrotactile feedback can simulate sonar-based spatial perception in VR, enabling users to navigate and interact through embodied, non-visual cues inspired by dolphin echolocation. The system offers a novel multisensory interface that fosters empathy and environmental awareness. In future work, we plan to evaluate user performance and emotional engagement through controlled studies, and explore adaptive feedback and bio-integrated sensing to expand biomimetic interaction in XR.

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References

[1] Adilzhan Adilkhanov, Matteo Rubagotti, and Zhanat Kappassov. 2022. Haptic Devices: Wearability-Based Taxonomy and Literature Review. *IEEE Access* 10 (2022), 91923–91947. doi:10.1109/ACCESS.2022.3202986

[2] Florian Alber, Sean Hackett, and Yang Cai. 2020. Haptic Helmet for Emergency Responses in Virtual and Live Environments. In *HCI International 2020 – Late Breaking Papers: Virtual and Augmented Reality*, Constantine Stephanidis, Jessie

Y. C. Chen, and Gino Fragomeni (Eds.). Springer International Publishing, Cham, 3–11.

[3] WHITLOW W. L. AU and. 1997. ECHOLOCATION IN DOLPHINS WITH A DOLPHIN-BAT COMPARISON. *Bioacoustics* 8, 1-2 (1997), 137–162. doi:10.1080/09524622.1997.9753357 arXiv:https://doi.org/10.1080/09524622.1997.9753357

[4] Mark Armstrong, Kinga Skiers, Danyang Peng, Tamil Selvan Gunasekaran, Anish Kundu, Tanner Person, Yixin Wang, Kouta Minamizawa, and Yun Suen Pai. 2023. Heightened Empathy: A Multi-user Interactive Experience in a Bioresponsive Virtual Reality. In *ACM SIGGRAPH 2023 Immersive Pavilion* (Los Angeles, CA, USA) *(SIGGRAPH '23)*. Association for Computing Machinery, New York, NY, USA, Article 9, 2 pages. doi:10.1145/3588027.3595599

[5] Yoseph Bar-Cohen. 2005. *Biomimetics: biologically inspired technologies*. CRC press.

[6] Matthias Berning, Florian Braun, Till Riedel, and Michael Beigl. 2015. ProximityHat: a head-worn system for subtle sensory augmentation with tactile stimulation. In *Proceedings of the 2015 ACM International Symposium on Wearable Computers* (Osaka, Japan) *(ISWC '15)*. Association for Computing Machinery, New York, NY, USA, 31–38. doi:10.1145/2802083.2802088

[7] Philippe Bertrand, Jérôme Guegan, Léonore Robieux, Cade Andrew McCall, and Franck Zenasni. 2018. Learning Empathy Through Virtual Reality: Multiple Strategies for Training Empathy-Related Abilities Using Body Ownership Illusions in Embodied Virtual Reality. *Frontiers in Robotics and AI* Volume 5 - 2018 (2018). doi:10.3389/frobt.2018.00026

[8] Cynthia Breazeal. 2003. Emotion and sociable humanoid robots. *International Journal of Human-Computer Studies* 59, 1 (2003), 119–155. doi:10.1016/S1071-5819(03)00018-1 Applications of Affective Computing in Human-Computer Interaction.

[9] Holly Cecil. 2021. The iAnimal Film Series. *Screen Bodies* (2021). https://api.semanticscholar.org/CorpusID:237923115

[10] Pratheep Kumar Chelladurai, Ziming Li, Maximilian Weber, Tae Oh, and Roshan L Peiris. 2024. SoundHapticVR: Head-Based Spatial Haptic Feedback for Accessible Sounds in Virtual Reality for Deaf and Hard of Hearing Users. In *Proceedings of the 26th International ACM SIGACCESS Conference on Computers and Accessibility* (St. John's, NL, Canada) *(ASSETS '24)*. Association for Computing Machinery, New York, NY, USA, Article 31, 17 pages. doi:10.1145/3663548.3675639

[11] Hsin-Ai Chen, Yu-Ting Peng, Yan-Ming Chen, Amanda Castellanos, Chih-Ching Chuang, Yi-Chao Chen, and Chuang-Wen You. 2024. Tell Me How You Play: Exploring Ways to Enhance the Gaming Experience in Asymmetric Multiplayer VR Games through Affective State Visualization. In *Companion of the 2024 on ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Melbourne VIC, Australia) *(UbiComp '24)*. Association for Computing Machinery, New York, NY, USA, 19–24. doi:10.1145/3675094.3677577

[12] Victor Adriel de Jesus Oliveira, Luciana Nedel, Anderson Maciel, and Luca Brayda. 2016. Spatial discrimination of vibrotactile stimuli around the head. In *2016 IEEE Haptics Symposium (HAPTICS)*. 1–6. doi:10.1109/HAPTICS.2016.7463147

[13] Stefan Greuter and Gerard T. Mulvany. 2024. Designing a Virtual Death VR Experience. In *Companion of the 2024 on ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Melbourne VIC, Australia) *(UbiComp '24)*. Association for Computing Machinery, New York, NY, USA, 328–332. doi:10.1145/3675094.3681945

[14] Heidi E Harley, Erika A Putman, and Herbert L Roitblat. 2003. Bottlenose dolphins perceive object features through echolocation. *Nature* 424, 6949 (2003), 667–669. doi:10.1038/nature01846

[15] Matthias Hoppe, Daria Oskina, Albrecht Schmidt, and Thomas Kosch. 2021. Odin's Helmet: A Head-Worn Haptic Feedback Device to Simulate G-Forces on the Human Body in Virtual Reality. *Proc. ACM Hum.-Comput. Interact.* 5, EICS, Article 212 (May 2021), 15 pages. doi:10.1145/3461734

[16] Mahshid Hosseini and Cornelia Caragea. 2021. Distilling Knowledge for Empathy Detection. In *Findings of the Association for Computational Linguistics: EMNLP 2021*, Marie-Francine Moens, Xuanjing Huang, Lucia Specia, and Scott Wen-tau Yih (Eds.). Association for Computational Linguistics, Punta Cana, Dominican Republic, 3713–3724. doi:10.18653/v1/2021.findings-emnlp.314

[17] Jangsun Hwang, Yoon Jeong, Jeong Min Park, Kwan Hong Lee, Jong Wook Hong, and Jonghoon Choi and. 2015. Biomimetics: forecasting the future of science, engineering, and medicine. *International Journal of Nanomedicine* 10 (2015), 5701–5713. doi:10.2147/IJN.S83642 PMID: 26388692.

[18] Gareth Jones. 2005. Echolocation. *Current Biology* 15, 13 (2005), R484–R488. doi:10.1016/j.cub.2005.06.051

[19] Yulan Ju, Dingding Zheng, Danny Hynds, George Chernyshov, Kai Kunze, and Kouta Minamizawa. 2021. Haptic Empathy: Conveying Emotional Meaning through Vibrotactile Feedback. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI EA '21)*. Association for Computing Machinery, New York, NY, USA, Article 225, 7 pages. doi:10.1145/3411763.3451640

[20] Oliver Beren Kaul and Michael Rohs. 2017. HapticHead: A Spherical Vibrotactile Grid around the Head for 3D Guidance in Virtual and Augmented Reality. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 3729–3740. doi:10.1145/3025453.3025684

[21] Myungho Lee, Kangsoo Kim, Hyunghwan Rho, and Si Jung Kim. 2014. Empa talk: a physiological data incorporated human-computer interactions. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI EA '14)*. Association for Computing Machinery, New York, NY, USA, 1897–1902. doi:10.1145/2559206.2581370

[22] Brayton Lordianto, Daniel Lu, Hui-Wen Wendy Ho, and Semiha Ergan. 2024. Hapti-met: A Construction Helmet with Directional Haptic Feedback for Roadway Worker Safety.

[23] Ashwath N. 2021. Biomimetics: An Approach to Enhance Sustainability - An Overview. *International Journal for Research in Applied Science and Engineering Technology* 9 (07 2021), 2760–2770. doi:10.22214/ijraset.2021.36947

[24] Paul E. Nachtigall. 2016. Biosonar and Sound Localization in Dolphins. *Oxford Research Encyclopedia of Neuroscience* (11 2016). doi:10.1093/acrefore/9780190264086.013.103

[25] Behnaz Nojavanasghari, Tadas Baltrušaitis, Charles E. Hughes, and Louis-Philippe Morency. 2016. EmoReact: a multimodal approach and dataset for recognizing emotional responses in children. In *Proceedings of the 18th ACM International Conference on Multimodal Interaction* (Tokyo, Japan) *(ICMI '16)*. Association for Computing Machinery, New York, NY, USA, 137–144. doi:10.1145/2993148.2993168

[26] Iffa Nurlatifah, Roopesh Sitharan, and Mirza Mazli. 2023. Virtual Reality in Empathy Towards Non-Human Being. *Proceedings of the 11th International Conference on Digital and Interactive Arts* (2023). https://api.semanticscholar.org/CorpusID:268890350

[27] Roshan Lalintha Peiris, Wei Peng, Zikun Chen, Liwei Chan, and Kouta Minamizawa. 2017. ThermoVR: Exploring Integrated Thermal Haptic Feedback with Head Mounted Displays. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 5452–5456. doi:10.1145/3025453.3025824

[28] Teddy Pozo. 2018. Queer games after empathy: Feminism and haptic game design aesthetics from consent to cuteness to the radically soft. *Game Studies* 18, 3 (2018).

[29] Otto H Schmitt. 1969. Some interesting and useful biomimetic transforms. In *Proceedings of the Third International Biophysics Congress*, Vol. 197.

[30] Bill Seaman. 2022. Overview: Neosentience, Biomimetics, and Insight Engine 2.0. *Proceedings* 81, 1 (2022). doi:10.3390/proceedings2022081089

[31] Dennis Wolf, Michael Rietzler, Leo Hnatek, and Enrico Rukzio. 2019. Face/On: Multi-Modal Haptic Feedback for Head-Mounted Displays in Virtual Reality. *IEEE Transactions on Visualization and Computer Graphics* 25, 11 (2019), 3169–3177. doi:10.1109/TVCG.2019.2932215