Spread Your Wings: Demonstrating a Soft Floating Robotic Avatar with Flapping Wings for Novel Physical Interactions

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Figure 1: The concept of using the soft floating robotic avatar for physical interaction: A pilot wearing a body-tracking interface embodies a fish-shaped avatar, "swimming" through the remote environment to engage with others in physical interactions.

Abstract

We demonstrate a new robotic avatar concept in which pilots can embody a fish-like form, “swimming” through indoor spaces to interact, play, and accompany others remotely. Our soft flapping-wing floating avatar offers three merits: (1) The soft body and blade-free design enable safe, close-proximity flight around people; (2) The wings not only provide propulsion but also serve as a medium for physical interaction, allowing affective gestures such as hugs, shoulder pats, and high-fives; and (3) The bioinspired design provides a more organic and lifelike movement compared to propeller-based avatars, potentially enhancing the sense of presence and evoking a feeling of interacting with a living creature. Furthermore, by mimicking the flapping flight of birds, pilots can control the avatar through body movements, while engaging in interactions with others through the avatar’s soft body and wings. This work opens new

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possibilities for telepresence and introduces a wing-based approach to remote physical interactions.

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1 Introduction

Avatar robots transform how people connect across distances, allowing pilots to embody physical forms in remote locations and foster social interactions. These robots can reshape how we maintain relationships, especially when physical separation or isolation creates barriers [Seo et al. 2024]. However, due to the existing form factors, their mobility in domestic environments and ability for safe, physical human-robot interaction remains limited. Most avatar robots are ground-based and rigid, making it difficult for them to navigate indoor spaces with stairs or complex terrains. Although flying avatars have been introduced, they typically rely on propeller-driven drones [Higuchi and Oku 2021] or blimps [Tobita et al. 2011]. Spinning blades pose safety risks and generate excessive noise, hindering close proximity interactions.

Spread Your Wings is a new avatar concept designed to enable safe physical interactions for people separated by distance. It features a flapping-wing floating robot optimized for indoor use [Xu et al. 2025] and a body-tracking control interface. The robot eliminates the safety risks associated with propeller blades by utilizing low-frequency flapping wings for propulsion and a helium-filled soft body for lift. The controllable wings allow pilots to perform social gestures, such as hugging or gently patting on one's shoulders—interactions not explored in prior research. We introduce a novel control interface where pilots mimic bird-like flapping motions to operate the avatar. This work opens new opportunities for telepresence by offering users the unique experience of embodying a floating, fish-like avatar that moves freely through the air and interacts with others using its wings.

2 System Overview

While bioinspired floating robots like Air_ray[1] offer quiet and organic movements, their wingspan of 4.2 meters limits indoor usability. To address this, we designed our avatar to pass through standard doorframes, ensuring the avatar can move freely between rooms. Reducing the robot's size posed challenges due to the limited lifting capacity of helium. To overcome this, we simplified the wing system to a single-degree-of-freedom flapping mechanism that can still provide effective thrust. The wings feature flexible trailing edges with a curved shape, enabling propulsion through passive deformation effects. To enable agile pitch control, we replaced traditional control surfaces with a servo-driven counterweight that shifts the avatar's center of mass inside the helium envelope.

[1]https://www.festo.com/us/en/e/about-festo/research-and-development/bionic-learning-network/highlights-from-2006-to-2009/air-ray-id_33851/

To map their body movements to the avatar, the pilot wears IMU-based trackers on both wrists and the chest, enabling control of the avatar. Flapping the arms moves the avatar's wings. When the pilot flaps both arms simultaneously with the same frequency and amplitude, the avatar's wings generate forward flight. Differential flapping, where each arm flaps at a different frequency or amplitude, induces yaw motion. The chest tracker captures the pilot's torso movements: leaning forward or backward adjusts the avatar's pitch, enabling it to descend or ascend (Figure 2). This interface provides control over wing angles, flapping frequency, and amplitude, allowing pilots to perform gestures with adjustable intensity and style. Mimicking bird-like motions facilitates more natural control and contributes to an immersive flying experience, as pilots use a head-mounted display to view the avatar's first-person perspective.

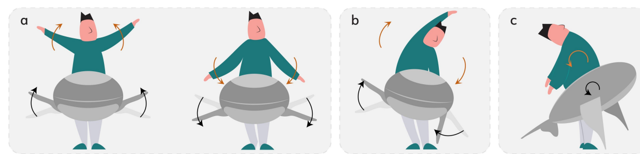

Figure 2: Mapping pilot movements to avatar actions: Flapping the arms controls the avatar's wing for (a) propulsion and (b) turn, while (c) tilting the torso adjusts pitch.

3 Use Scenarios

We envision our avatar as a novel medium for fostering emotional bonds across distances. For example, a parent working overseas could remotely control the avatar to play with their child at home. The child might chase or jump to touch the avatar floating in mid-air, as they share a joyful game of tag. Parents could also use their "wings" to hug their child, enabling affectionate interactions that go beyond what screen-based communication can offer.

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