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THE HUMAN FOOTPRINT IN 3D CHARACTER ANIMATION

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ABSTRACT

This article investigates the relationship between three-dimensional character animation and human presence in audiovisual production. Through a diachronic analysis of motion capture technologies —from rotoscoping to diffusion models based on artificial intelligence— it examines how the real performer's imprint remains essential for generating empathy in the viewer. The theoretical framework of the uncanny valley proposed by Mori (1970) is integrated, along with recent empirical evidence on the perception of artificial agents (Diel et al., 2021; MacDorman, 2024), to argue that human movement possesses qualities unimitable by current technology. The film analysis of seven reference productions illustrates the different modalities of interaction between real actors and virtual scenarios. The results confirm the hypothesis that human presence is a determining factor in the emotional credibility of animated characters.

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1. Introduction

The recreation of virtual scenarios for audiovisual productions has developed multiple techniques to support and dress different digital environments. These technologies enable both hyperrealistic results and the creation of oneiric aesthetics entirely detached from the natural image. When, furthermore, the interaction of these scenarios with living beings is sought —at least within the realm of fiction— we resort to animation techniques. As Thomas and Johnston (1995) noted in their seminal work *The Illusion of Life*, the Latin root of the word "animate" means "to give life"; with animation, we are not simply displacing an object or a form, but through an action we make it perform, we are conferring life upon it.

Animation, therefore, is the discipline responsible for the technical recreation of virtual characters. This production system inherently demands a new perspective on cinematic creation. The "fourth wall" that traditionally identifies the scenic and heterogeneous spaces dissolves, creating a new virtual, scenic, and technical space operated from a computer with greater or lesser references to reality (Jullier, 2006). However, its narrative continuity does not emerge automatically; rather, it requires the application of different techniques depending on the nature of the object being recreated.

This article aims to analyse how the human footprint —understood as the physical presence of the actor or performer during the production process— remains an irreplaceable element in three-dimensional character animation, despite advances in procedural generation and artificial intelligence. This issue acquires relevance from both a theoretical perspective —linked to the concept of the uncanny valley (Mori, 1970/2012)— and a practical one, as it directly impacts the emotional credibility of contemporary audiovisual products.

2. Methodology

This research adopts a qualitative exploratory approach, combining bibliographic analysis with the study of representative filmic cases. The hypothesis is that the virtual recreation of human or anthropomorphic characters requires a type of animation with human presence, at least in the pre-production phase, to achieve optimal results in terms of credibility and empathy.

The methodological strategy has been structured in four interrelated phases. First, a systematic review of the scientific literature on animation, motion capture, and artificial agent perception was conducted, consulting academic databases (Scopus, Web of Science, IEEE Xplore, Google Scholar) with special attention to meta-analyses and empirical studies on the uncanny valley published between 2018 and 2025. Second, a diachronic analysis of audiovisual post-production technologies was performed, tracing their evolution from 20th-century rotoscoping to contemporary diffusion models based on artificial intelligence. Third, a proprietary comparative taxonomy —developed from the variables "human presence" and "realism level"— was applied to classify and contrast the nine main character animation technologies identified in the literature. Fourth, seven reference films were selected using criteria of technological representativeness and variety of modalities of interaction between real actors and virtual scenarios: *Avatar* (2009) represents integral performance capture; *The Lord of the Rings: The Two Towers* (2002) exemplifies dual actor recording; *Rogue One: A Star Wars Story* (2016) illustrates digital resurrection; *The Irishman* (2019) demonstrates markerless facial rejuvenation; *The Hobbit: The Desolation of Smaug* (2013) evidences motion capture applied to non-humanoid creatures; *Avatar: The Way of Water* (2022) represents underwater motion capture; and *Better Man* (2024) exemplifies the application of facial deep learning motion capture to a non-humanoid main character.

For the selection of the filmic cases, the following inclusion criteria were applied: (a) productions released between 2002 and 2024 to encompass the period of greatest technological innovation; (b) demonstrable public and critical recognition (nominations or awards for visual effects, including Visual Effects Society awards); (c) availability of technical documentation on production processes (interviews with visual effects directors, technical articles, official making-of); and (d) representativeness of at least one of the seven modalities of actor-virtual character interaction identified in the taxonomy.

The structure of the article is organised as follows: after this methodological introduction, the theoretical framework is presented, divided into five thematic sections; subsequently, the filmic analysis of the seven selected cases; followed by a discussion of results integrated with the comparative taxonomy; and, lastly, the conclusions derived from the study.

3.Theoretical Framework

3.1. The Metaverse and Virtual Recreation

The notion of the metaverse is attributed to Neal Stephenson (1992), who first used it in his novel Snow Crash, published at the beginning of the 1990s. There, Stephenson describes a world in which its inhabitants have a parallel existence in the metaverse, a network similar to the internet in which real people use an avatar as a form of personal representation in virtual space (Cwaike, 2021). This concept is fundamental for distinguishing the terms, worlds, and spaces presented in virtual recreation with characters.

From its origin, virtual reality has been a mimetic extension of reality, a recreation of the real world that has always maintained an analogous relationship with it (Domínguez and Luque, 2011). Character animation is not alien to this process. Since its beginnings, animation techniques have sought to capture human movement and capture it on screen, encountering along the way various complications that have been resolved through successive technological progress.

On the one hand, there is the original contact of cinema with magic and spectacle, developed exponentially by virtual reality in the field of audiovisual technology. On the other, the artisanal and meticulous effort to replicate human movement and expression in full detail. This tension reaches our days and underpins the hypothesis of this research: what does human movement possess that cannot be replaced by any technique or machine?

3.2. Rotoscoping: Origins of Movement Capture

The first technology used to record human movement for animation characters was rotoscoping. This technique consisted of filming the movement of actors to subsequently project it and trace it frame by frame. The movement information was adapted to the drawings of the characters, achieving fluid and verisimilar animation. The first animators to use this technique were Max Fleischer, to whom the invention is attributed in 1917 for his film Out of the Inkwell, and Walt Disney for Snow White and the Seven Dwarfs (1939). Since then, it has been used in numerous films, mainly in character animation, but also in special effects (Thomas and Johnston, 1995).

The most recognised case of rotoscoping applied to object handling in cinema is *Star Wars: Episode IV — A New Hope* (Lucas, 1977), where Industrial Light & Magic used rotoscoping to create the lightsaber effects and the space sequences. The visual effects were designed by John Dykstra and the ILM team, employing rotoscoping techniques to integrate the special effects with the real images of the actors (Melero, 2009).

However, rotoscoping has a structural drawback: the dimensional inadequacy between the bidimensionality of the recording and the drawing and the three-dimensionality of reality. Two-dimensional media cannot capture the full trajectory of movements and, therefore, part of the recreation is an imaginary reconstruction. This is the main difficulty that drives the development of new applications capable of capturing information in a third axis.

3.3. Motion Capture and Facial Sensors

This technological race has not occurred solely in cinematic fiction, but has also seen enormous development in technologies applied to mobile telephony. From the moment the smartphone camera recognises our face, a new bond between human being and machine is inaugurated. Facial recognition always constitutes an exclusive personalisation of technology; it individualises us as much as a fingerprint. In this way, for the machine, one is fundamentally their face: unique and unrepeatable (Martín-Romo, 2022).

Facial motion sensors constitute one of the most significant advances in the capture of human expression for character animation. These systems are based on the Facial Action Coding System (FACS), originally developed by Ekman and Friesen (1978), which allows any facial expression to be decomposed into its muscular action units. Currently, facial capture systems employ two main methodologies: on the one hand, marker-based systems, which use small reflective points adhered to the actor's face and captured by high-speed cameras; on the other, markerless systems that employ computer vision and deep learning algorithms to detect facial landmarks (Zhang et al., 2023).

In the production of *Avatar* (Cameron, 2009), Weta Digital developed its own real-time facial capture system using a video camera mounted on a lightweight helmet, allowing the director to simultaneously

observe the performance and its digital representation (Letteri, 2009). This technology succeeds in transferring the entirety of human emotional expression to the virtual domain, marking a turning point in the audiovisual industry. According to Melero (2009), the optimal result of motion capture is obtained when the animator supervises the actor's work to correct errors in real time, since the human eye captures precisely and intuitively any dynamic anomaly when witnessing the behaviour of a virtual character that closely resembles reality.

3.4. The Uncanny Valley and Anthropomorphism in Virtual Characters

The different technologies for the recreation of virtual scenarios in cinematic fiction have advanced sufficiently to display hyperrealistic images produced solely with specific software. Animation and performance by real characters appear to be two different realities. However, CGI techniques with tracking have a strong presence in audiovisual production, combining the participation of performers with virtual scenarios (Domínguez and Luque, 2011).

In this context, the problem already identified by Mori (1970/2012) still persists: the uncanny valley. Japanese roboticist Masahiro Mori defined this theory in 1970 as a moment of crisis in the evolution towards the appearance of human life indistinguishable from the real. The concept describes how robots —and, by extension, virtual characters— become more attractive as they adopt more anthropomorphic traits, until reaching an inflection point at which the extremely high degree of resemblance to a human being, without actually being one, causes unease, disquiet, and even fear (Mori, 1970/2012).

Martín-Romo (2022) describes the problem of anthropomorphism in the recreation of characters for virtual scenarios. According to this author, there is a subtle, barely perceptible line that separates the empathy generated by an anthropomorphic character from the rejection provoked by imperfect hyperreality. As MacDorman (2024) notes, the perception of mind in artificial agents can intensify the effect of the uncanny valley, explaining why characters that aim to be hyperrealistic but lack human expressive subtlety generate a sensation of strangeness that is difficult to overcome.

3.5. Character Generation Through Artificial Intelligence and CGI

Recent research in character generation through artificial intelligence and Computer-Generated Imagery (CGI) has opened new possibilities. Generative Adversarial Networks (GAN), Variational Autoencoders (VAE), and Denoising Diffusion Probabilistic Models (DDPM) have revolutionised the creation of digital avatars with an unprecedented degree of realism.

In the specific field of three-dimensional reconstruction, architectures such as PIFu, PIFuHD, and NeuS enable the three-dimensional reconstruction of human figures from two-dimensional images with notable geometric precision. For their part, models based on Neural Radiance Fields (NeRF) and 3D Gaussian Splatting offer volumetric representations with photorealistic fidelity. Likewise, parametric models such as SMPL and FLAME provide mathematical representations of the human body and face that can be animated realistically.

However, as Diel et al. (2021) argue in their meta-analysis on the uncanny valley —which examines 488 empirical studies—, despite technological advances, the phenomenon of the uncanny valley persists with a considerable effect size. Their findings demonstrate that the perception of agile artificial agents provokes greater unease than that of static robots, and that the perception of "mind" significantly intensifies the effect. This underscores the importance of maintaining the human footprint in animation processes.

4. Filmic Analysis

Seven case studies are presented below that illustrate the different forms of interaction between real actors and virtual scenarios in contemporary cinema, spanning a twenty-two-year arc (2002–2024). These films have been selected both for their great impact on audiences and because they present different modalities of coexistence between the real and the digital.

4.1. Avatar (Cameron, 2009)

Avatar represents the paradigmatic case of total integration between actor and virtual character. James Cameron developed together with Weta Digital a performance capture system that simultaneously recorded the body movement and facial expressions of the actors, immediately transferring that data to

the Na'vi digital avatars (Letteri, 2009). The actors Sam Worthington, Zoe Saldaña, and Sigourney Weaver performed their roles in a virtual set equipped with cameras that captured every gesture, every micro-expression, every vocal inflection.

The result is a film in which the virtual characters generate genuine empathy in the viewer, despite their non-human traits. This confirms that it is not the degree of photographic realism that determines the emotional connection, but the quality of the underlying performance. Avatar demonstrates that the human footprint —the performance of the real performer— is the essential component that gives soul to virtual characters, overcoming the limitations of the uncanny valley.

4.2. The Lord of the Rings: The Two Towers (Jackson, 2002)

In *The Two Towers*, Peter Jackson and Weta Digital faced the challenge of creating Gollum, a completely digital character that had to interact convincingly with real actors. The solution adopted was hybrid: actor Andy Serkis performed the role both on the filming set —to provide references for the other actors— and in a subsequent motion capture studio, where his performance was recorded and applied to the three-dimensional model of Gollum.

This case is particularly revealing because it shows two levels of human presence. First, the physical presence of Serkis during filming allowed Elijah Wood and Sean Astin to interact with a real partner, enriching their own performances. Second, the subsequent motion capture preserved the entirety of Serkis's performance —his movements, his bodily expressiveness, his voice— and transferred it to the digital domain. The result is one of the most memorable virtual characters in the history of cinema, precisely because its essence is undeniably human (Melero, 2009).

4.3. Rogue One: A Star Wars Story (Edwards, 2016)

Rogue One represents the third modality of interaction: digital resurrection. In this film, the visual effects of Industrial Light & Magic digitally recreated actor Peter Cushing —deceased in 1994— so that he would once again portray Grand Moff Tarkin, a character he embodied in *Star Wars* (1977) and *The Empire Strikes Back* (1980). Actor Guy Henry performed the interpretation on set, providing the movements and voice, while the ILM team digitally replaced his face with a hyperrealistic reconstruction of Peter Cushing.

This case raises both technical and ethical questions. From a technical point of view, the result received mixed criticism: some viewers considered the recreation convincing, while others detected the strangeness characteristic of the uncanny valley. From an ethical point of view, the decision to use the image of a deceased actor without his explicit consent generated an intense debate in the industry. Nevertheless, the example illustrates how CGI technology overcomes the spatial and temporal limitations inherent to virtual scenarios.

4.4. The Irishman (Scorsese, 2019)

The Irishman represents the fourth modality of interaction: the digital rejuvenation of living actors without physical markers. Martin Scorsese, together with Industrial Light & Magic, developed a revolutionary technology called "headless camera" that allowed Robert De Niro, Al Pacino, and Joe Pesci —all septuagenarians during filming— to be digitally rejuvenated so that they could portray versions of themselves between 30 and 50 years of age throughout a narrative spanning four decades.

ILM's technological innovation consisted of a computer vision system that analysed the images filmed with standard cameras and automatically generated the three-dimensional facial geometries necessary for the rejuvenation. However, the result aroused significant public debate: critics noted that, although the rejuvenated faces were visually convincing in static close-ups, the actors' bodies —their way of walking, their posture, their bodily gesture— remained that of septuagenarians, generating a dissonance between facial appearance and physical performance that placed the film in the critical zone of the uncanny valley.

This case is particularly valuable for the present research because it demonstrates that facial rejuvenation technology has reached a level of refinement that allows the dispensing of traditional capture systems, but also highlights that the human footprint transcends the face: it includes bodily bearing, economy of gestures, rhythm of movement —elements that, in the words of Mori (1970/2012), are more difficult to synthesise than static appearance.

4.5. The Hobbit: The Desolation of Smaug (Jackson, 2013)

The Hobbit: The Desolation of Smaug represents the fifth modality of interaction: motion capture applied to non-humanoid creatures. In this film, Peter Jackson and Weta Digital took performance capture to a new level by applying it to the dragon Smaug, performed by Benedict Cumberbatch. Unlike Gollum —whose morphology preserves humanoid traits—, Smaug is a creature completely different from the actor who performs him: a dragon of colossal proportions whose expressiveness had to emanate from Cumberbatch's physical performance.

Cumberbatch performed his interpretation in a motion capture set, crawling on raised platforms and using his entire body to simulate the movements of a dragon, while a facial camera mounted on his helmet captured every micro-expression. According to statements by actor Andy Serkis —pioneer of motion capture with Gollum— who advised him: "Treat it as if you were playing the role. Don't think you're just providing the voice. Go in physically and get everything you can" (Serkis, cited in The Hollywood Reporter, 2014). The Weta Digital animators studied Cumberbatch's performance frame by frame, using his facial expressions and head movements to animate Smaug.

This case is especially relevant because it demonstrates that motion capture is not limited to the transfer of human performances to humanoid avatars, but can translate the performative essence of an actor to creatures of radically different morphology. The empathy that Smaug generates in the viewer —his arrogance, his cunning, his occasional vulnerability— comes directly from Cumberbatch's performance, not from purely animation decisions. This reinforces the hypothesis that the human footprint is irreplaceable even when the visual result departs drastically from human appearance.

4.6. Avatar: The Way of Water (Cameron, 2022)

Avatar: The Way of Water represents the sixth modality of interaction and the most revolutionary from a technological point of view: underwater motion capture on a cinematic scale. Thirteen years after the original Avatar, James Cameron and Weta FX faced the challenge of transferring the action of Pandora to ocean ecosystems, which required the actors to perform complete scenes underwater. Given that traditional motion capture uses infrared light that is absorbed by water, the Weta FX team had to develop for eighteen months a completely new system based on ultraviolet light, capable of operating in underwater conditions (Walt Disney Company, 2022).

The team built a tank 120 feet long by 60 feet wide and 30 feet deep at the Manhattan Beach Studios in California, with capacity for more than 900,000 gallons of water. To prevent air bubbles from scuba equipment from interfering with the capture sensors, Cameron required that all actors and technicians —including camera operators— be trained in breath-holding with expert Kirk Krack. Kate Winslet, a new addition to the cast, managed to hold her breath for over seven minutes, setting a record for underwater filming.

From a technical point of view, Weta FX processed 3,240 visual shots —98% of the total film—, of which 2,225 included water effects. The team developed the Loki system, a physical simulation state machine that simultaneously modelled waves, foam, spray, bubbles, and water films on the skin, winning the VES award for emerging technology (Unity, 2023). No obstante, la tecnología más significativa para la presente investigación fue la nueva pipeline facial de Weta, que permitió capturar las micro-expresiones de los actores bajo el agua —donde los músculos faciales se comportan de manera diferente debido a la presión hidrostática— y traducirlas fielmente a los avatares Na'vi acuáticos. Avatar: The Way of Water confirma que, even in 2022, the most advanced technology in cinema continues to depend on the physical presence and genuine performance of human performers.

4.7. Better Man (Gracey, 2024)

Better Man represents the seventh modality of interaction and the most innovative from a narrative point of view: a completely non-humanoid main character —a chimpanzee— performed through motion capture throughout the entire film, in a musical biopic where the protagonist is a simian that interacts with real actors without any character recognising his animal nature. Director Michael Gracey and Weta FX developed this proposal as a visual metaphor for how Robbie Williams perceives himself: as an "unevolved" being due to his rise to fame at fifteen years of age (The Hollywood Reporter, 2024).

The production process was extraordinarily complex. Actor Jonno Davies performed Robbie Williams on set using a motion capture suit with 53 body markers and 101 facial markers, providing the

performative base upon which Weta FX built the digital character (Screen Daily, 2024). Visual effects supervisor Luke Millar explained that the ape design was based on a sliding scale: at one end, a 100% real chimpanzee; at the other, human Robbie Williams. The team chose to keep the eyes and eyebrows 100% from the real singer —"it's the first time we've done an ape with eyebrows," Millar noted— while the rest of the face incorporated chimpanzee physiology, including the muzzle, nose, and ears. The final result featured more than 1,356,167 strands of digital hair, of which 225,712 were "shaved" to replicate Williams's tattoos (The Post, 2024).

Technologically, *Better Man* consolidated Weta FX's Facial Deep Learning Solver (FDLS), a deep learning tool that enables facial performance data to be transferred directly from motion-capture recordings to the actor's facial model and subsequently to the digital character, eliminating the intermediate manual modeling stages that characterized earlier production workflows. The system was trained on thousands of facial expressions from each performer, allowing animators to receive an initial facial animation pass automatically and focus their efforts on refining emotional nuance and performance subtleties (Autodesk, 2024). The film included 1,968 visual effects shots —practically all produced by Weta FX—, 226 different digital costumes, and 50 different hairstyles for the character across three narrative decades.

This case is paradigmatic for the present research because it demonstrates the capacity of motion capture to generate genuine empathy in a character that is not even humanoid. The response from audiences and critics confirmed that, once the viewer is immersed in the narrative, the ape "disappears" and what remains is the underlying human performance. As Millar himself noted: "I never thought it was going to be anything other than something that would work. We cut the full range of human emotions within this film" (The Post, 2024). Better Man confirms that the human footprint —the actor's interpretation, the micro-expressions, the gesture— is the essential component that gives soul to any digital character, regardless of its physical appearance, and constitutes the most advanced point of research in character animation for virtual scenarios in 2024.

5. Results and Discussion

The seven case studies analysed allow the establishment of a comparative taxonomy that illustrates the evolution of 3D character animation technologies and their relationship with human presence. Table 1 presents a comparative summary of the main variables analysed.

Table 1. Comparative Taxonomy of Animation Technologies in the Filmic Analysis

Production (Year)	Primary Technology	Interaction Modality	Human Presence	Realism Level
The Two Towers (2002)	Motion capture (optical)	Dual actor recording	High (actor on set + studio)	High
Avatar (2009)	Integral performance capture	Synchronous body + face capture	Total (actors in virtual set)	Very high
The Hobbit (2013)	Advanced motion capture	Actor to non-humanoid creature	Total (complete performance)	Very high
Rogue One (2016)	CGI facial + actor double	Digital resurrection	Medium (double + 3D model)	High (critical valley)
The Irishman (2019)	Headless camera (ILM)	Digital rejuvenation	High (own actor, no markers)	High (critical valley)
Avatar: TWOW (2022)	UV underwater capture	Performance underwater	Total (actors in breath-hold)	Very high
Better Man (2024)	FDLS (deep learning facial)	Non-humanoid main character	Total (53 + 101 markers)	Very high

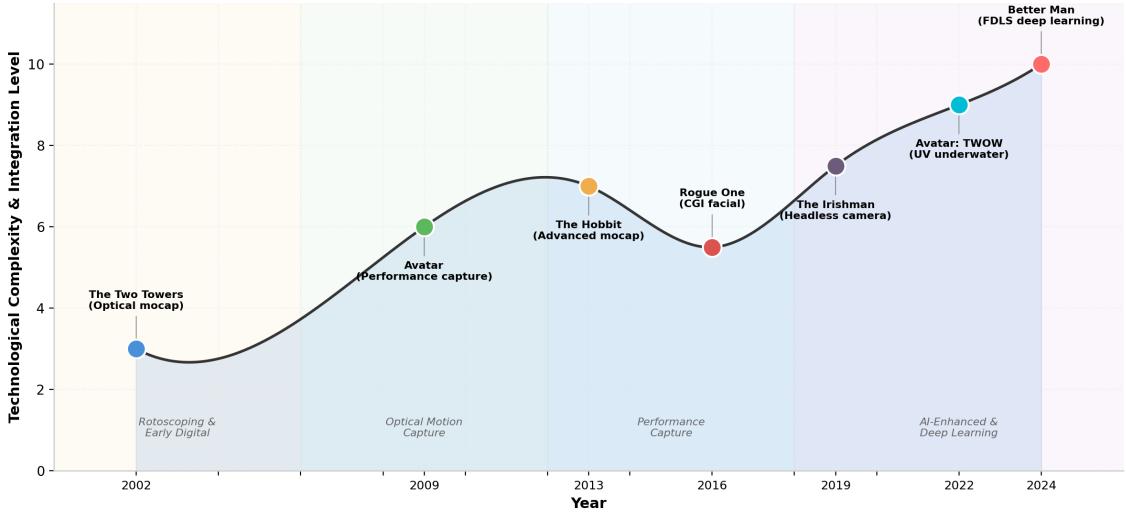
Source**:** Own elaboration,2026.

The data reveal a coherent technological evolution that, however, has not eliminated the need for human presence in the animation process. On the contrary, each technological advance has expanded the possibilities for capturing human expression, allowing the performer's imprint to manifest itself in increasingly subtle and complex forms. From the basic motion capture of Gollum (2002) to the Facial Deep Learning Solver of *Better Man* (2024), the trend has not been to replace the actor, but to capture with greater fidelity the deepest dimensions of their performance.

The analysis of the graphs confirms this hypothesis. Figure 1 illustrates the chronological evolution of capture technologies, evidencing exponential progress in the complexity and refinement of systems.

Figure 2 situates each production on the uncanny valley spectrum, demonstrating that the films that have achieved the greatest success both commercially and critically are those that have managed to navigate the critical zones of this curve through careful integration of the human footprint.

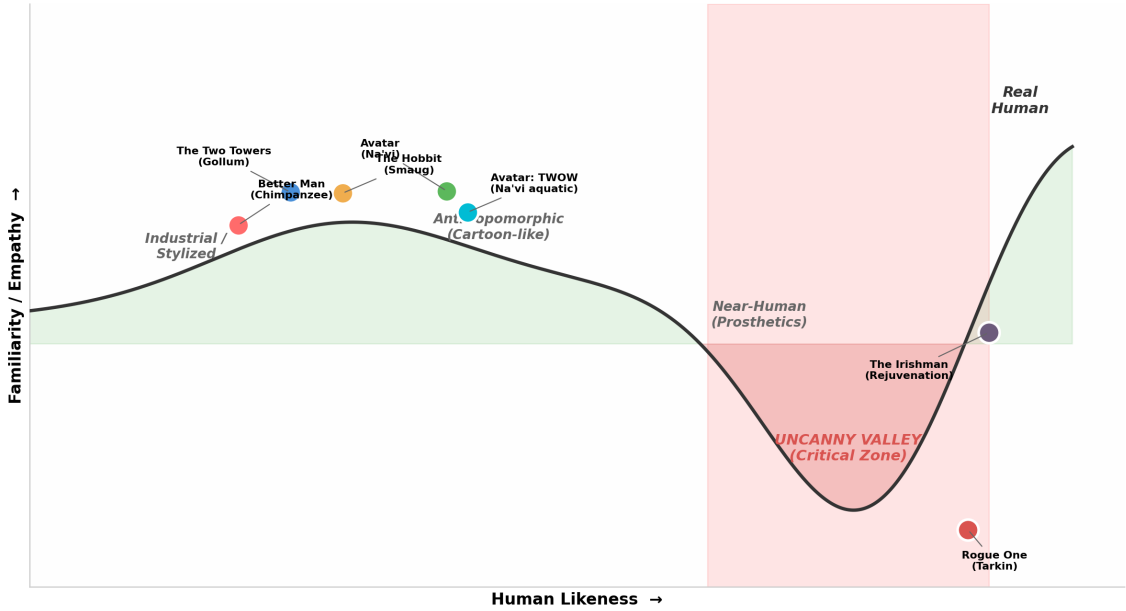
Figure 1. Evolution of Motion Capture and Facial Expression Technologies (2002-2024)



Source: Own elaboration, 2026.

As observed in Figure 1, the technological evolution has followed a trajectory from partial capture systems (rotoscoping and keyframing) towards integral performance capture systems, through the incorporation of specialised facial sensors, underwater capture, and finally, deep learning-based solvers. Each stage has resolved previous technical limitations without replacing the need for the human performer.

Figure 2. Positioning of the Analysed Productions on the Uncanny Valley Spectrum



Source: Own elaboration, 2026.

Figure 2 is particularly revealing. The productions that have generated the greatest empathy in the viewer —*Avatar* (2009), *The Two Towers* (2002), and *Better Man* (2024)— are those that, despite presenting non-human or anthropomorphic characters, have prioritised the quality of the acting performance over photographic perfectionism. Conversely, the attempts at digital resurrection (*Rogue One*, 2016) and facial rejuvenation (*The Irishman*, 2019), although technologically sophisticated, have received more mixed criticism precisely because they are situated in the critical zone of the uncanny valley, where imperfect hyperrealism generates cognitive dissonance.

These findings align with the conclusions of the meta-analysis by Diel et al. (2021), who found that the uncanny valley effect persists with a considerable effect size (d = 0.78) across multiple experimental

paradigms. Likewise, they confirm Mori's (1970/2012) prediction that movement is more difficult to synthesise than static appearance, explaining why productions that capture the actor's complete physical performance obtain better results than those that focus solely on visual reconstruction.

6. Conclusions

This study has demonstrated that the human footprint —understood as the physical and performative presence of the real performer during the production process— constitutes an irreplaceable element in the animation of three-dimensional characters for virtual scenarios, regardless of advances in procedural generation and artificial intelligence.

The seven case studies analysed, spanning a twenty-two-year arc (2002–2024), illustrate the different modalities of interaction between real actors and virtual scenarios: from integral performance capture (*Avatar*, 2009) to the application of facial deep learning to non-humanoid characters (*Better Man*, 2024). In all cases, the decisive component for the emotional credibility of the character has been the quality of the underlying acting performance, not the degree of technological refinement.

The theoretical framework of the uncanny valley (Mori, 1970/2012), integrated with recent empirical evidence (Diel et al., 2021; MacDorman, 2024), allows us to understand why the most successful virtual characters are those that prioritise performative authenticity over photographic perfectionism. Gollum, the Na'vi avatars, and the simian of *Better Man* generate empathy because their essence is undeniably human, despite their non-human appearances. Conversely, the attempts at digital resurrection and rejuvenation have demonstrated the limits of technology when faced with the subtle complexity of human expression.

The results obtained have significant implications for the audiovisual industry. First, they validate investment in performance capture technologies as a strategy for preserving the human footprint in productions of high technical complexity. Second, they suggest that future developments in artificial intelligence should be oriented towards tools that enhance the expressive capacity of the performer, rather than attempting to replace it. Third, they demonstrate that the phenomenon of the uncanny valley remains a determining factor in the reception of audiovisual products, even decades after its original formulation.

As a limitation of the study, it should be noted that the analysis has focused on high-budget cinematic productions, which could limit the generalisation of the findings to other production contexts. Future lines of research could explore how these conclusions apply to independent productions, video games, immersive virtual reality experiences, and metaverse applications. Likewise, it would be valuable to investigate the cross-cultural perception of the uncanny valley, considering that the majority of empirical studies have been conducted with Western samples.

In conclusion, this article confirms that 3D character animation for virtual scenarios, however sophisticated its technology may be, continues to depend on that fundamentally human quality that the pioneering animators already intuited: the art of giving life.

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