Moldy Ghosts and Yeasty Invasions: Glitches in Hybrid Bio-Digital Games

Raphael Kim
Queen Mary University
London, United Kingdom
r.s.kim@qmul.ac.uk

Roland van Dierendonck
Studio Roland van Dierendonck
Amsterdam, The Netherlands
roland@rolandvandierendonck.com

Stefan Poslad
Queen Mary University
London, United Kingdom
stefan.poslad@qmul.ac.uk

ABSTRACT

Hybrid bio-digital games integrate real, biological materials into computer systems. They offer a rich, playful space in which interactions between humans, computers, and non-human organisms can be explored. However, the concept of video game 'glitching' in hybrid bio-digital games, specifically those that result from interactions between the biological and the computer hardware and/or software, have not been explored in great detail. We report two incidences of glitches observed during *Mold Rush* – a hybrid bio-digital game based on growth patterns of living mold: The creation of an additional game character (*Moldy Ghosts*), and the gameplay freeze (a *Yeasty Invasion*). As we interpret our observations, we question the potential for glitches to become valuable tools in framing HCI investigations into designing a productive and meaningful biological-digital interactions. The goal of this paper is to propose three testable routes in which glitches could be implemented. 1) Glitch as a tool for learning 2) Glitch as a precursor for an experience-enhancing game component, and 3) Glitch as an instigator for discourse on ethical implications of bio-digital games.

CHI'19 Extended Abstracts, May 4-9, 2019, Glasgow, Scotland, UK.

ACM ISBN 978-1-4503-5971-9/19/05.
DOI: https://doi.org/10.1145/3290607.3312895

KEYWORDS

Hybrid games; bio-digital; gaming; glitches; HCI; Bio-HCI; Micro-organisms

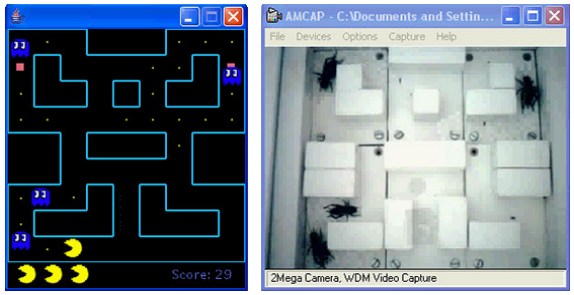

Figure 1: *Bug-Man* game in action [20]. Left: Digital representation of cricket-controlled game. Right: Physical game with real crickets (in black).

Figure 2: Flatbed photo scanner with two culture dishes, one upside down and one upright showing mold growth. When the dish is upside down (during imaging), a 3mm gap is present between the surface of the scanning bed and the culture dishe, allowing space for mold to grow. This microbe imaging technique was introduced by van Eck and Lamers [22].

[1] https://www.mariowiki.com/Minus_World
[2] https://glitches.fandom.com/wiki/Swordless_Link
[3] https://en.wikipedia.org/wiki/MissingNo.

1 INTRODUCTION

1.1 Glitches and Hybrid Bio-Digital Games

In video gaming, the definition of glitches and its interpretation is far from settled. However, as Svelch [18] argues, one of the widely-accepted feature of a video game glitch (hereafter called 'glitch') is its "*perceived unpredictable changes in video game behavior that may or may not be faulty, but are in any case part of the art form, and source of digital aesthetic qualities*". Some of the most iconic glitches include *The Minus World* in *Super Mario Bros*[1], *Swordless Link* in *The Legend of Zelda*[2], and *Missingno* in *Pokemon Blue Version*[3], to name a few.

Glitches are not only observed in exclusively computer-driven systems, but also in those that combine the digital and biological worlds together. In hybrid bio-digital games – a relatively new genre of video game that integrate biological materials and/or processes into computer systems [16] – glitch-like incidences have been reported: Van Eck and Lamers report of an 'unexpected outcome' during *Bug-Man* game [20]. A modified version of the classic *Pac-Man* game, *Bug-Man* involves stimulation of live crickets by players using vibrations, which triggers the insects to navigate a physical maze. The insects' movements are video-captured and translated into digital characters, effectively creating two parallel gaming environments (Fig. 1). The *Bug-Man* 'glitch' was caused by a single cricket, which had shed its skin mid-game. Due to the light color of its new body, the animal had evaded digital capture by the image recognition software, whilst the old skin remained as an immobile (yet an accountable) character in the game.

It is suggested that such biologically-driven, unexpected outcomes can offer value in artistic and entertainment computing [21]. However, to the authors' knowledge, a definitive strategy outlining what these values are, and how glitches of this nature could be used to frame meaningful Human-Computer Interaction (HCI) and Bio-HCI [13] investigations, have not yet been published.

1.2 Mold Rush Game Testing

Mold Rush is an online strategy game based on mold growth [9]. As the organisms grow over time, they are monitored by a computer that scans them (Fig. 2), and live-broadcasts their growth progress on a popular streaming channel, *Twitch*. The entire gameplay takes online, where players compete to virtually collect as many of the mold cells that appear on the computer screen as possible (Fig. 3). Each player's collected patch of mold is tracked continuously by an image processing software, which subsequently converts the mold coverage into points (Fig. 4).

Eight student volunteers (3 male, 5 female) from several universities across London played *Mold Rush* game, as part of the game testing phase of its development. The volunteers were divided into two groups of four, with each group playing a single game session of *Mold Rush,* which lasted three days. Gameplay and player observations were documented.

2 FINDINGS

Two incidents of glitches were encountered by the volunteers. The following describes them.

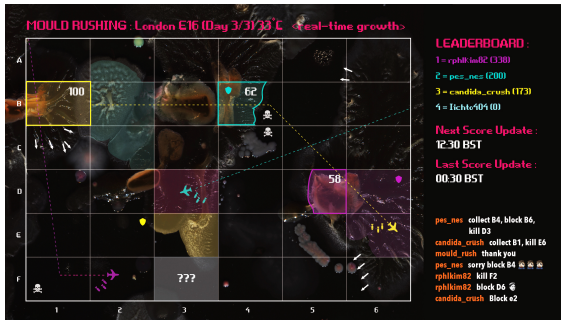

Figure 3: Screenshot of a typical Mold Rush game play, as seen on Twitch stream. Players type commands on a chat box (bottom right hand corner)

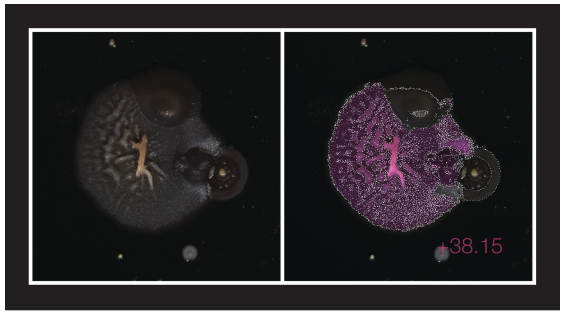

Figure 4: Image processing algorithm (Open CV) calculates area of mold growth (left), which are subsequently converted into points (right).

** Measured using digital thermometer at mid- point of a Mold Rush game. Two sites on the scanning bed were measured, one at the furthest end from the main electronics circuit (found at the right-hand side of the scanner, Fig. 2) and one at the nearest of the circuit. 3 measurements were made for each site and averaged.

2.1 Glitch I. "Moldy Ghost"

This glitch had created a 'ghost' character within the game: Unlike other nearby mold cells, the ghost did not grow during the game, but rather seemed to remain in its original state (Fig. 5). Upon closer inspection of the game's hardware, the ghost turned out to be a layer of dried, dead mold.

This layer of mold had been imprinted and adhered to the surface of the scanning bed, which was caused by an overgrowth, allowing physical contact between the top layer of mold cells and the glass surface of the scanning bed to be made (Fig. 6). Crucially, the image processing software could not distinguish between viable cells and those that were dead, given the similar visual features the ghost mold shared with the live mold.

Interestingly, a further investigation found up to 4°C difference in temperature** across the scanning bed, with the lowest and highest temperature recorded in an area furthest and closest to the scanner's main electronic circuit, respectively. Further still, the ghost character was found in the half of the scanning bed closer to the electronic circuit, although additional experiments would be necessary to suggest any significant correlations between the proximity of the cells to electronic circuits, and as well as on the role of temperature, in triggering overgrowth of mold.

2.2 Glitch II. "Yeasty Invasion"

This glitch resulted in a 'fuzzy' game scene (Fig. 7), making it difficult for the image processing software to detect cells, and effectively freezing the gameplay. Later, it transpired that the game hardware had been contaminated by yeast species with an unusual growth behavior. The fuzziness had been caused by a slimy layer of semi-translucent yeast cells. They had aggressively taken over the entire culture plate, eliminating any visually recognizable cells in their wake, whilst themselves evading the game engine's image processing algorithm.

We suspect that the source of the contamination may be from the scanner. Despite a thorough clean of the machine prior to the start of each game, narrow openings allowed the cells to be exposed to the internal structures of the scanner and the dust, which were harder to clean.

3 DISCUSSION

Overall, the observations we report from *Mold Rush* gaming can be summarized in Fig. 8, which shows intervention from exterior biological entity (i.e., microbial presence and behavior) in shaping the gameplay. It is important to note that the individual phenomenon shown in Fig. 8 in creating the *Moldy Ghosts* and *Yeasty Invasions* cannot be acknowledged as glitches in their own right.

However, the combined effect of all phenomena from the computer and the microbes have significantly altered the narrative and functioning of the gameplay as intended by the developer.

As such, we state that 1) Bio-digital game glitches are distinguishable from conventional video game glitches in that they are triggered from external biological materials and/or processes, and 2) *Moldy Ghost*s and *Yeasty Invasions* can be regarded as bio-digital game glitches.

With an increasing integration and connection of biological materials into computer systems [4] and Internet of Things (IoT) framework [14,19,24], the line between bio- and digital worlds are

Figure 5: Scanned image of a part of the 'Moldy Ghost' (in pale orange), as it appeared during the game. Once it had appeared, they did not seem to grow over time, unlike other cells around them.

Figure 6: Dried, dead layer of mold cells. Left: small patches of Moldy Ghosts. Right: A larger structure of Moldy Ghosts, covering a top right hand corner of the scanning bed. These layers of mold were adhered onto the glass surface of the scanning bed, likely to have been caused by mold overgrowth.

continuously blurring. Further still, micro-organisms such as Slime Molds, and mammalian cells, are being considered as potential substitutes for electronic components [1,6] and even as a form of programmable bio-computers themselves [2]. As such, we recognize the value of initiating conversations within the HCI community, in navigating this relatively unchartered field of interaction that involves humans, computers and biological materials.

Our observations are a reminder of how sensitive biological materials can be, especially when integrated into computer systems. They also confirm the importance of finding the appropriate hardware and software solutions to counter biological variability, a heuristic recommended by Gerber *et al.* in designing biotic games [7].

Given the inherently unpredictable nature of glitches in games, they may be perceived as a hindrance. However, glitches do not have to be avoided, but harnessed instead. As argued by Menkman [11], glitches should be actively utilized, in order to create new aesthetics [5], to critique inherent politics of a specific medium, and to better understand a technological flow. We propose three testable routes in which glitches from hybrid bio-digital games could be harnessed. These may lead to meaningful and productive HCI and bio-HCI investigations in the future.

3.1 Glitch as a Tool for Learning

The 4°C difference in temperature, as observed inside the scanner used for *Mold Rush* games, may not produce problematic shifts in computer behavior. Yet such difference can be significant in the biological world, including speed of microbial growth [15]. Similarly, there are other physical characteristics of computer hardware that may influence biological behavior, such as electromagnetic radiation [3], presence of chemicals, and materiality of surfaces [17].

As such, observing glitches may not only teach us about general microbiology, but more significantly on the nuanced interactions between microbes and the computing environments. A possible way to enhance such learning is a workshop, designed to compare biological behaviors with and without integration of electronic or digital components. Some of the questions that could be asked include: How sensitive are the two systems with each other? What causes abnormal behaviors, and what are the insights that could be gained?

3.2 Glitch as a Precursor for Experience-Enhancing Game Component

As demonstrated by van Eck and Lamers' study [23], players expect unpredictability from hybrid bio-digital games, and such trait has also been shown to contribute to players' enjoyment [10]. In a similar vein, the unpredictability of glitches that are found in *Mold Rush* may be harnessed to enhance gaming experience, which can be measured, as shown by Kim *et al.* [10].

The accidental discoveries of Moldy Ghosts and Yeast Invaders have essentially provided the game with extra 'characters' that could be implemented permanently in *Mold Rush*. These may add additional challenge and visual intrigue to the gameplay, which in turn could improve playing experience. The implementation could be direct. For example, hidden 'hot spots' that generate additional heat could be strategically located on the scanner by the game designer, to surprise players and the audience.

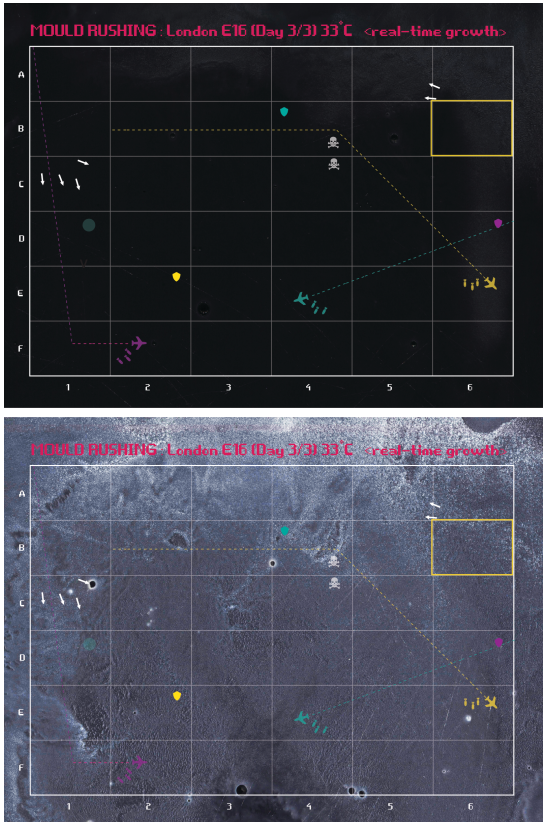

Figure 7: A 'Yeasty Invasion', which resulted in 'freezing out' of the game, due to malfunctioning of the game engine. Top: game prior to Yeasty Invasion, showing clear screen. Bottom: A fuzzy game screen that is covered by yeast contamination during a Yeasty Invasion.

An indirect approach could involve deliberate over-heating of the computer hardware by overworking the electronics. And lastly, the sterility of the game system could be deliberately reduced in order to encourage contamination.

We acknowledge that these game components are not glitches, given their deliberate nature in which they would be incorporated, but rather the products created from the original glitches.

3.3 Glitch as an Instigator for Discourse on Ethical Implications of Bio-Digital Games

The discovery of bio-glitches had prompted the game testers to comment on the ethical and safety aspects [8] of hybrid biological digital gaming. The remarks seemed to focus on possible future scenarios ("*These dried moldy ghost cells, someone one day will sell these on the black market, as a dodgy copy of the original game character!*"; "*Maybe the cells inside the computer will react to its electromagnetic radiation, and create mutants*").

Given the unexpected nature of how glitches manifest during the game, we recognize that they initiate discourse on ethical and safety implications from a fresh, alternative perspectives that may not have been anticipated beforehand. Furthermore, due to the minor and transient nature in which these glitches seemed to appear, we hypothesize that they create a form of 'safe space', in which small scale bio-digital malfunctions could be observed first hand, without them escalating into a major ethical or a safety challenge. This concept could be applied to other hybrid bio-digital games too, in order to widen the discourse on ethics and safety.

4 CONCLUSION

As we report on the two incidences of glitches in a hybrid bio-digital game *Mold Rush*, we highlight the significance of engaging in an active dialogue to practically address the concept of glitching in the context of bio-digital interactions. We propose three testable routes which are formulated to encourages designers to fully embrace and harness glitches in creating a meaningful and productive HCI and Bio-HCI investigations.

REFERENCES

[1] Andrew Adamatzky. 2013. Physarum wires: Self-growing, self-repairing, smart wires made from slime mould. arxiv:1309.3583. Retrieved from https://arxiv.org/abs/1309.3583

[2] Simon Auslaender, David Auslaender, Marius Mueller, Markus Wieland, and Martin Fussenegger. 2012. Programmable Single-Cell Mammalian Biocomputers. *Nature*, 487, 123-127. doi:10.1038/nature11149

[3] Shyamal Banik, Sanghamitra Bandyopadhyay, and Sangram N. Ganguly. 2003. Bioeffects of Microwave. *Bioresource Technology*. 87(2), 155-159.

[4] Curtis D. Chin, Vincent Linder, and Samuel K. Sia. 2007. Lab-on-a-chip Devices for Global Health: Past Studies and Future Opportunities. *Lab Chip* 7, 41-57. DOI: 10.1039/B611455E

[5] Jonas Downey. 2002. Glitch Art. *Ninth Letter*.

[6] Ella M. Gale, Andrew Adamatzky, and Benjamin P. D. L. Costello. 2014. Slime Mould Memristors. BioNanoScience. arixv:1306.3414. Retrieved from https://arxiv.org/abs/1306.3414

[7] Lukas C. Gerber, Honesty Kim, and Ingmar H. Riedel-Kruse. 2016. Interactive Biotechnology: Design Rules for Integrating Biological Matter into Digital Games. *DiGRA/FDG*, Vol 13, Number 1 (August 2016), 16 pages.

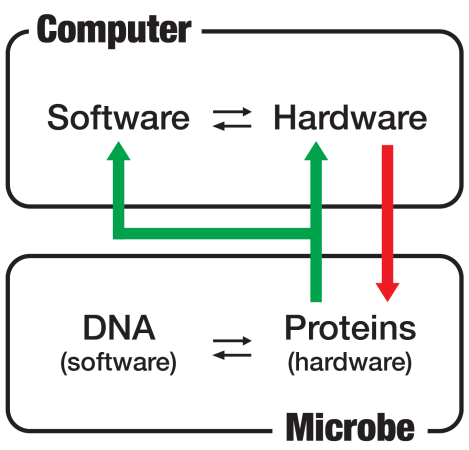

Figure 8: A simplified schematic depicting internal and external interactions between computer and microbe during *Mold Rush* gameplay. In green: Biological interventions that are responsible for creation of *Moldy Ghosts* (misinterpretation of game characters by image processing algorithm, and adherence of cells on scanning bed), and *Yeasty Invasions* (freezing of image processing algorithm). In red: Effects of computer hardware (e.g. electronics and non-sterile mechanical parts) on growth behavior of microbes.

ACKNOWLEDGMENTS

This research was supported by EPSRC and AHRC Centre for Doctoral Training in Media and Arts Technology (EP/L01632X/1).

[8] Hayden Harvey, Molly Havard, David Magnus, Mildred K. Cho, and Ingmar Riedel-Kruse. 2014. Innocent Fun or Microslavery? An Ethical Analysis of Biotic Games. *Hastings Center Report* 44 (6), 38-46.

[9] Raphael Kim, Siobhan Thomas, Roland van Dierendonck, and Stefan Poslad. 2018. A New Mould Rush: Designing for a Slow Bio-Digital Game Driven by Living Micro-organisms. *In Proceedings of the 13th International Conference on the Foundations of Digital Games (FDG '18).* https://doi.org/10.1145/3235765.3235798.

[10] Raphael Kim, Siobhan Thomas, Antonios Kaniadakis, Roland van Dierendonck, and Stefan Poslad. 2018. Microbial Integration on Player Experience of Hybrid Bio-Digital Games. *INTETAIN.* 12 pages.

[11] R. Menkman. 2011. Glitch Studies Manifesto. *Video Vortex Reader II: Moving Images Beyond Youtube.* 336-347.

[12] Merriam-Webster Dictionary: Definition of Glitch. https://www.merriam-webster.com/dictionary/glitch

[13] Pat Pataranutaporn, Todd Ingalls, and Ed Finn. 2018. Biological HCI: Towards Integrative Interfaces Between People, Computer, and Biological materials. In *Extended Abstracts of the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'18).* ACM, New York, NY, USA. https://doi.org/10.1145/3170427.3188662

[14] S. Poslad. 2009. Ubiquitous Computing: Smart Devices, Environments and Interactions. John Wiley & Sons Ltd, West Sussex, United Kingdom.

[15] P. Buford Price and Todd Sowers. 2004. Temperature Dependence of Metabolic Rates for Microbial Growth, Maintenance, and Survival. *PNAS.* 101 (13), 4631-4636.

[16] Ingmar H. Riedel-Kruse, Alice M. Chung, Burak Dura, Andrea L. Hamilton, and Byung C. Lee. 2011. Design, Engineering and Utility of Biotic Games. *Lab Chip.* 11, 14-22. DOI: 10.1039/c01c00399a.

[17] R. M. Sterritt and J. N. Lester. 1980. Interactions of Heavy Metals with Bacteria. *Sci Total Environ.* 14 (1), 5-17.

[18] Jan Svelch. 2015. Negotiating a Glitch: Identifying and Using Glitches in Video Games with Microtransactions. In *New Perspectives in Game Studies: Proceedings of the Central and Eastern European Game Studies Conference Brno 2014.* Masaryk University. 55-70.

[19] Anthony P. F. Turner. 2013. Biosensors: Sense and Sensibility. *Chem. Soc. Rev.* 42, 3184-3196. DOI: 10.1039/C3CS35528D

[20] Wim van Eck and Maarten H. Lamers. 2006. Animal Controlled Computer Games: Playing Pac-Man Against Real Crickets. In R. Harper, M. Rauterberg, and M. Combetto (eds.). ICEC. LNCS (4161) 31–36. Springer, Heidelberg, Germany. https://doi.org/10.1007/11872320_4

[21] Wim van Eck and Maarten H. Lamers. 2013. Hybrid Biological-Digital Systems in Artistic and Entertainment Computing. Leonardo. 46, 2 (2013), 151-158. DOI: 10.2307/23468152.

[22] Wim van Eck and Maarten H. Lamers. 2015. Biological Content Generation: Evolving Game Terrains Through Living Organisms. In: C. Johnson et al. (Eds): EvoMUSART 2015, LNCS, 9027. 224-235. Springer International Publishing Switzerland. DOI: 10.1007/978-3-319-16498-4-20.

[23] Wim van Eck and Maarten H. Lamers. 2017. Player Expectations of Animal Incorporated Computer Games. In: Chisik Y., Holopainen J., Khaled R., Luis Silva J., Alexandra Silva P. (eds.) Intelligent Technologies for Interactive Entertainment. *INTETAIN* 2017. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 215. Springer, Cham (2017).

[24] Diming Zhang and Qingjun Liu. 2016. Biosensors and Bioelectronics on Smartphone for Portable Biochemical Detection. *Biosensors and Bioelectronics.* 75, 273-284.