Revolutionizing Pinball: A Journey Through Advanced Mechatronic Design
Technical Paper

Navigating Ethical Waters: Gamble-Like Aspects in Pinball Design
STS Paper

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Gambling, often seen as a game of chance, has been a deeply rooted activity in human history. From ancient dice games in the Indus Valley civilization, to modern-day casinos in Las Vegas, the thrill of uncertainty and the potential for gain has captivated millions. Over the years, with technological advancements, gambling has intertwined with digital platforms, leading to innovations such as online casinos and digital slot machines. In a setting such as college, where students already grapple with stresses ranging from academics to social pressures, the attraction of such games raises many questions. How does gambling, and its digital counterparts, influence mental health? How do the psychological triggers used in gambling mechanics impact decision-making and financial behaviors in individuals? In 2022, a study conducted by the Problem Gambling New York State Resource Center revealed that about 75% of U.S. college students gambled during the past year, with 18% of students gambling on a weekly basis, and with 6% of students reporting a serious gambling problem (PGRC, 2022). This striking statistic underlines the growing concern of gambling behaviors in younger adults. Yet, as gaming has evolved, elements of gambling have been subtly infused into what many consider to be innocent games, with pinball standing out among them.

Pinball, with its flashing lights, dynamic gameplay, and reward mechanisms, resembles many aspects of traditional gambling. Pinball's history has even intersected with anti-gambling sentiments. In the early to mid-20th century, pinball was banned in various cities, including New York and Los Angeles, with authorities defining it as a game of chance rather than skill, hence categorizing it as gambling (Aeon, 2016). While modern perceptions of pinball are more subtle, these historical intersections emphasize the thin line it treads between harmless entertainment and potential gambling stimuli. When looking deeper into the dynamics of game design, Bogost's

insights shed light on how technologies, particularly games, are not merely neutral systems. Embedded in their design are social, political, and psychological nuances. In games like pinball, with its historical ties to gambling sentiments, these psychological dimensions become increasingly noticeable (Bogost, 2007). While games like pinball provide a medium of entertainment, the responsibility also lies on developers to recognize their societal implications. Corporate Social Responsibility (CSR) extends beyond environmental or philanthropic efforts. This philosophy explains the fabric of a product's design, and its repercussions on its user base (Creative Commons, 2021). This beckons the question: Do pinball and similar game developers have a corporate responsibility to ensure the mental well-being of their players, especially in vulnerable groups such as college students?

In response to these considerations, our technical endeavor focuses on creating a pinball machine for the student lounge at UVA. Drawing from a 2016 project as our foundation, our goal extends beyond mere entertainment (UVA, 2016). We aspire to offer enjoyment through safe avenues, distancing ourselves from the pitfalls of gambling. As the machine finds its place in 1515, a haven for students to relax and socialize, our goal relies on one vision. We are striving to offer joy with our technological achievement, while definitively distinguishing innocent amusement from potential compulsions.

Technical Discussion

Designing a UVA-themed pinball machine presents a multidimensional challenge that combines mechanical engineering, software design, and cultural representation. While the 2016 endeavor provided a foundational blueprint, our aspirations aim to both refine and elevate the previous model. The aesthetic of pinball, historically, has been enriched by its thematic

references: iconic movies, TV shows, and popular games. Our ambition is to channel the essence of UVA into this traditionally cinematic space. Navigating this transformation presents unique challenges. Moving beyond universal UVA experiences like football games or the iconic Rotunda, we are confronted with the intricate task of mechanically encapsulating a full UVA experience.

The 2016 pinball model was pioneering in its approach, but with such ambition came technical pitfalls that hindered its performance (UVA 2016).

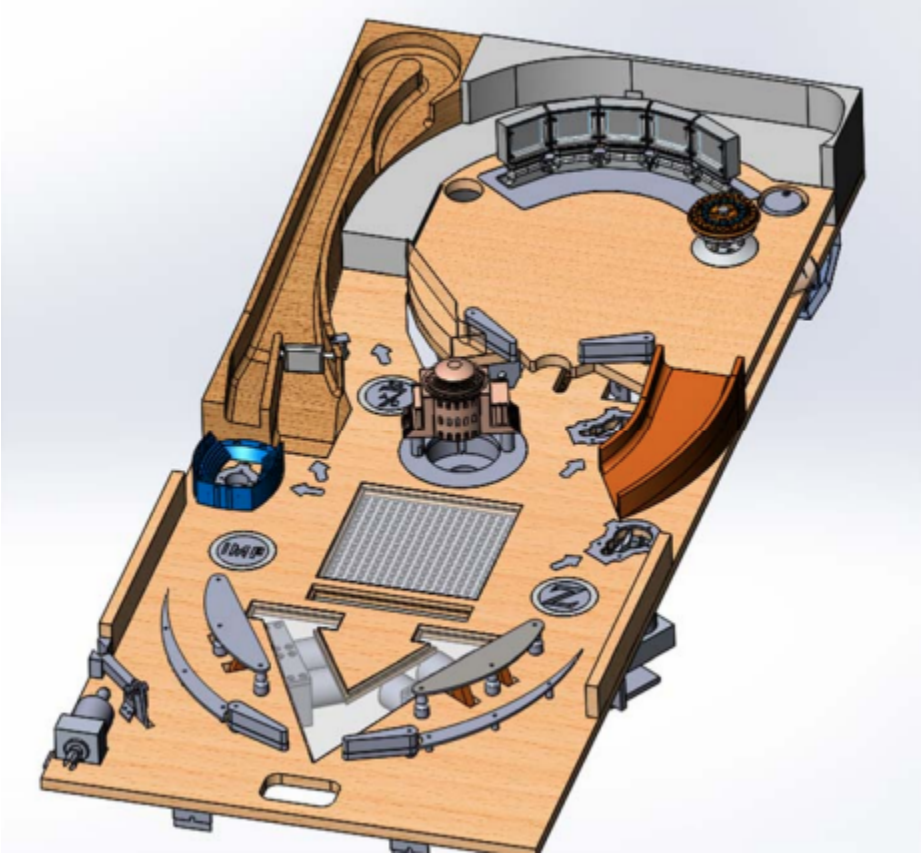

Figure 1: UVA MAE 2016 Pinball CAD Assembly

Taking these prior challenges as a learning curve, we aim to re-engineer key elements to craft a model that combines both innovation with reliability. Starting with the drop target mechanics, the 2016 design was undeniably sophisticated, incorporating intricate metalwork, high-resolution

digital screens, individual motors for each target, and a sturdy aluminum base. However, its complexity was unnecessary. The overengineered system was not only space-consuming, but also posed a higher risk for mechanical discrepancies. When we consider the vibrational stresses and impacts a pinball machine undergoes during active gameplay, it is clear that a simpler design would translate to fewer points of failure (Sclater, 2011). To address this, we are employing modern CAD tools that will help streamline the design, ensuring we make the most out of every square inch.

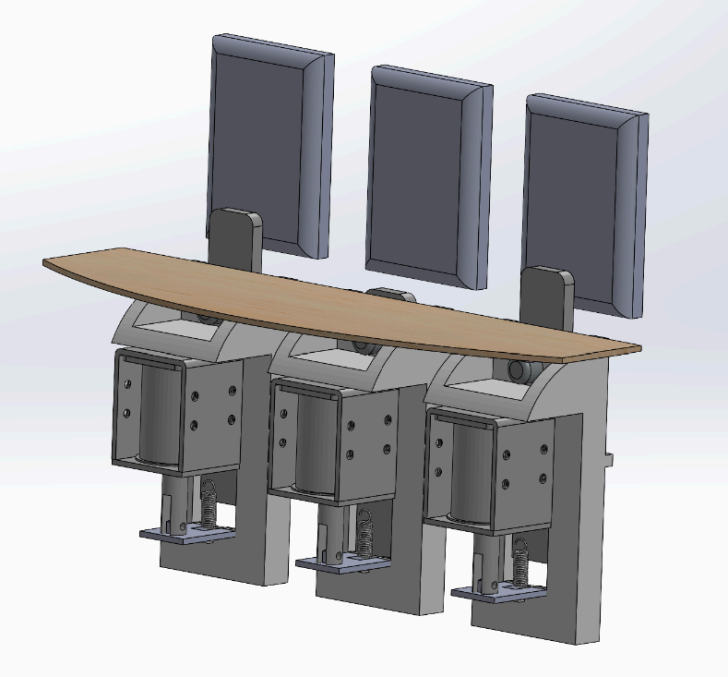

Figure 2: Example CAD models for Drop Target experimentation

Additionally, we plan to use linear actuators, offering precise movement and durability while minimizing the machine's footprint and mechanical intricacies (Sclater, 2011). The ball launcher mechanism's inconsistent performance in the 2016 model was another point of contention. While it was designed to introduce the ball with a combination of force and trajectory that would make each game unique, its frequent jams detracted from the overall gaming experience. We recognize that in the realm of pinball, consistency is important to the user’s experience. A player should be

confident that each launch gives them a fair start. Therefore, our engineering focus will be on crafting a ball launcher system that is mechanically simple, yet proficient. By employing precision-engineered components and ensuring smoother interaction between parts, we aim to eliminate jams and provide a consistent launch trajectory every time. Continuing off of playability, the flipper's importance cannot be understated, serving as the primary interface between the player and the machine. The prior model's flippers, though innovative, lacked the responsiveness and durability that players expect. Our approach to addressing this was to incorporate self-made solenoids. These are electromechanical devices that, when optimized, can provide rapid, forceful, and consistent actuation (Schimpf, 2013).

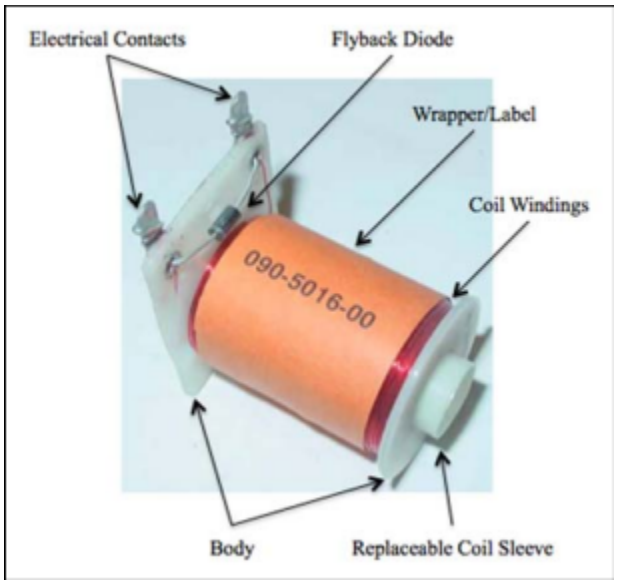

Figure 3: Open-Frame Linear Solenoid (Lakeside Pinball Parts, 2015)

By tailoring the solenoid's characteristics to our needs, we can ensure that each flipper's movement is both swift and sustainable.

The ramp and rail systems, fundamental to guiding the pinball's trajectory and ensuring a smooth gameplay experience, presented challenges in the earlier design. Specifically, the lack of robust construction and improper sanding altered the ball's path, leading to inconsistencies in

gameplay. Addressing this, our approach leverages precision machining to ensure the ramp and rail surfaces are impeccably smooth. Another crucial addition to our design is the innovative ball return system. Traditional pinball machines rely on gravity-fed systems, which can sometimes be slow or inconsistent. Our modern approach utilizes infrared (IR) sensors to detect the ball's position in real-time (Sclater, 2011). This feedback-driven system ensures precision and quick results for the ball return, enhancing the pace of the game. Working in similarity with the IR sensors, are the advanced incorporation of distance sensors. These sensors will not only detect the ball's position, but also its velocity, offering an unprecedented level of interaction and responsiveness. The data from these sensors can be seamlessly integrated into our scoring system, ensuring that players are rewarded accurately for their skills.

Beyond the mechanics, the thematic elements of the pinball machine are crucial to authentically capture the essence of the UVA experience. The rotating elements, like the Rotunda, are operated by stepper motors, adding depth to the gameplay (Williams, 2005). Advanced audio engineering will also be integrated into the machine to infuse humor and elevate the gameplay through comedic sound bites. LED configuration is a pivotal part of our thematic overlay. Through the integration of programmable RGB LEDs, we can adapt color schemes to represent various stages or milestones within the game. Moreover, high-definition LED matrices will display real-time scores and game metrics, immersing players into the heart of the UVA experience. In sum, by converging state-of-the-art technology with meticulous design, our aim is to overcome the traditional boundaries of pinball mechanics, offering players an unparalleled UVA-themed gaming experience with mechatronics and CAD.

STS Discussion

The line between pure entertainment and gambling is not always clear, and pinball's history serves as an example of this blurred distinction. Pinball, despite being largely skill-based, was consistently categorized alongside chance-based gambling activities. This historical classification underlines the broader societal and ethical considerations tied to the game's design and implementation. With the present project of crafting a pinball machine for UVA's student lounge, these concerns should be seen as a priority, urging the engineering team to strike a balance between entertainment and ethical responsibility (Creative Commons, 2021).

Revisiting pinball's past uncovers a multitude of ethical debates, particularly around its status as a form of gambling. Several cities, as previously mentioned, banned pinball machines, equating their random gameplay dynamics with gambling's unpredictability (Aeon, 2016). The predominant argument here revolved around pinball's reliance on chance versus skill. The very act of launching a ball into a playfield bursting with unpredictable bumpers and obstacles, for some, was compared to the roulette wheel's uncontrollable spin. With this comparison in mind, where does one draw the line? At its core, any game, even those rooted in skill, incorporates an element of chance. The trajectory of a basketball, the roll of dice in board games, or even the unpredictable nature of multiplayer video games all engages the player in a dance between skill and unpredictability (Drummond, A., Sauer, J. D., Ferguson, C. J., & Hall, L. C. 2020). Pinball exists within this spectrum, and its precise placement on the spectrum between skill and chance remains subjective.

The appeal of gambling stems largely from its psychological impact. The rewards, where players receive unpredictable and varied payouts, are known to be especially addictive (Zendle, D., & Cairns, P., 2018). This randomness keeps players engaged, always chasing the next high.

Slot machines are most characteristic in this regard, where the potential reward, however infrequent, keeps players anchored. Pinball, with its flashing lights and dynamic rewards (like bonus multipliers or special modes), shares some similarities with this reward structure. Every game is unique, with the potential for high scores or special achievements always within reach. Yet, it is the player's skill, rather than pure chance, that predominantly dictates the outcome. Nevertheless, the psychological impact of these rewards cannot be ignored. Even if the player is not betting money, the thrill of achieving a high score, especially in a communal environment like a student lounge, can encourage obsessive play (PGRC, 2022). The line between healthy competition and compulsive behavior is thin, and the design of the pinball machine must tread this boundary with care. To distance our pinball machine from any gambling subtleties, certain design choices are vital. Firstly, while rewards and bonuses are intrinsic to pinball, they should be structured in ways that prioritize skill over random chance. Features that may appear to offer a "jackpot" reward, especially those triggered unpredictably, should be minimized or redesigned to be skill-dependent. Moreover, feedback mechanisms can be implemented to encourage responsible play (Bogost, 2007). For instance, after a certain number of consecutive games, the machine could display friendly reminders to take a break or engage in other activities. Such soft interventions can dissuade excessive play without reducing the overall enjoyment of the game (Meyer, G., & Hayer, T., 2011). Additionally, educational elements can be embedded within the game. Periodic screens or sound bites emphasizing the skill-based nature of pinball, or even humorous quips about the difference between pinball and gambling, can subtly reinforce the machine's safe entertainment status.

As innovators, developers wield the power to shape player experiences. This power carries a significant ethical burden. By crafting games that prioritize the player's well-being,

developers can foster healthy gaming environments. This commitment should go beyond mere legal obligations and venture into the realm of moral responsibility (Creative Commons, 2021). In the context of our UVA-themed pinball machine, this translates into designing a machine that offers enjoyment without inadvertently encouraging addictive or compulsive behaviors. It is not about diluting the game's excitement, but about sculpting an experience that is both enriching and ethically sound. In the evolving landscape of games and entertainment, the responsibility rests on developers to ensure their creations prioritize player safety and well-being. As we endeavor to bring the UVA experience to life through our pinball machine, our commitment is unwavering. We aim to offer an engaging, thrilling, yet ethically responsible gaming experience. In this delicate balance between fun and responsibility lies the true essence of innovative game design.

Research Question and Methods

The core question guiding this analysis is: How can we design a pinball machine for UVA's student lounge that offers engaging entertainment without mimicking gambling elements? Historical literature highlights pinball's contentious association with gambling, and feedback from past UVA students and engineers will be instrumental in shaping our project's direction. We will systematically review available literature to identify specific pinball features that were criticized or led to the game being classified alongside gambling activities. This will help in understanding and isolating elements that should potentially be avoided or modified. Using CAD software, we will craft a playfield layout that promotes skill-based challenges like precision shots and timed tasks. Through simulations, we can predict the ball's trajectory and optimize the positions of ramps, bumpers, and targets to enhance strategic gameplay. Electronically, the

machine's firmware will be tailored to prioritize these skill-based achievements. Calibration of sensors will ensure accuracy, and the scoring system will be fine-tuned to reward dexterity over luck. Real-time feedback on the machine's interface will highlight player objectives and progress, emphasizing skill components. By merging historical insights with modern technical design, we aim to deliver a pinball experience for the UVA student lounge that is both engaging and safe, using precision engineering to highlight the game's skill-driven nature.

Conclusion

The endeavor of designing a pinball machine for UVA's student lounge represents a union of technological mastery and ethical responsibility. Our technical deliverable, a skill-focused pinball machine, harnesses CAD simulations and electronic calibrations to prioritize playability and strategic gameplay. This precision engineering ensures the game is distanced from the gambling elements historically associated with it. Simultaneously, the STS discussion illuminated the necessity of this distinction, revealing the fine line between innocent entertainment and potentially addictive gaming elements. By conscientiously designing a machine that emphasizes skill over randomness, we are addressing societal concerns tied to gambling. This pinball machine won't merely be a source of recreation; it will stand as an example to how engineering, when informed by societal insights, can craft solutions that are technically sound, ethically responsible, and culturally aware. This approach not only enriches the UVA student lounge experience, but potentially sets a precedent for future game designs, emphasizing that enjoyment and ethical responsibility can coexist seamlessly.

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