The Burgeoning Curriculum: Building a Pinball Machine as an Exercise in Mechatronics (Technical Topic)

Investigating the Potential Connection Between Immersive Sound and Music Design in Video Games and the Improvement of Auditory Attention Skills Through Focused Play (STS Topic)

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By
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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

Mechatronics is a relatively new, rapidly expanding field, combining mechanical engineering, electrical engineering, and computer science into an entirely new discipline. Education in mechatronics typically starts with a foundation in mechanical engineering, before transitioning into the areas of electrical engineering and computer science (Wikander and Törngren, 2001). Simply studying these three fields alone is not enough, however; combining the three into mechatronic designs and solutions requires a distinctive set of skills (Acar and Parkin, 1996). The purpose of building a pinball machine, in my capstone project's context, is less for the benefit of any external party and more for the benefit of the project's contributors, providing them with an interdisciplinary experience: an exercise in mechatronics. In a similar vein, just as educational institutions are working to develop and improve methods for mechatronics education, solutions to other skill training problems may lie in an unexpected place; although there is little to no evidence to suggest that the average child will learn more from their video games than from a conventional education, there is a strong basis of research suggesting that video games may have a positive impact on skills we use in our everyday lives (Parong and Mayer, 2017). However, there's an aspect of game design that has become more prevalent with the increasing computing power of consoles, and one that I feel merits a closer look: sound and music design. Can music and sound play a part in teaching vital, translatable skills through the medium of video games?

Technical Topic

Dr. Kevin Craig, of Rensselaer Polytechnic Institute, argued in his 2001 article that, in light of a changing industry, all mechanical engineers “must become mechatronics engineers.” While such a drastic shift “might not be entirely necessary or even feasible,” other scholars agree

that mechanical engineers should at least develop an appreciation for other engineering disciplines, and an ability to work well in a team- the latter of these being absolutely essential in the field of mechatronics (Acar and Parkin, 1996). In this age of increasing automation and prevalence of “smart” devices, the demand for mechatronic solutions seems stronger than ever. Within my own career, I have witnessed firsthand the heavy demand for automated solutions to manufacturing problems, and it’s a skill market that I don’t believe will be going away any time soon. Since the turn of the century, colleges and other institutions have been putting forward proposals in answering the question "how do we bridge the gap” (Wikander and Törngren, 2001). Despite these efforts, finding an institution with a well-defined mechatronics curriculum is harder than you might imagine, even in this day and age. In fact, I’ve found that many of my peers don’t even know what I mean when I use the term “mechatronics.” Western nations, in particular, are lagging behind, and it may be essential for countries like the United States to more heavily prioritize the education of mechatronics if they are to catch up, or at least keep up, in the changing global market (Acar and Parkin, 1996). This mentality has been present in the academic community for more than two decades, and it remains a pressing concern. Still, through trial and error, the educational community is making progress, and the answer may lie with a heavy emphasis on the practical. For example, a presentation at the Interdisciplinary Engineering Design Education Conference reported both high student success rates and high student growth self-evaluation scores for a capstone project that brought engineers of different disciplines together to create robots that operated using Arduino[1] infrastructure (Grover et al., 2014). Similarly, Rensellaer has been implementing a lab-based mechatronics curriculum since the beginning of the century (Craig, 2001).

[1] Arduino is a microcontroller brand, often favored by hobbyists and engineering beginners

With that in mind, why use the construction of a pinball machine as an exercise in mechatronics? A quick look at a pinball hobby site, such as Steve Young's "The Pinball Resource" gives a clear picture of what elements are required just for maintaining a pinball machine, let alone building one from the ground up. Electromagnetic coils, circuit boards, fuses, capacitors, lights, and motors are just a handful of examples of what goes into a pinball machine's design. To add an additional level of computer-aided control, which is an element of mechatronics not necessarily present in some traditional cabinets, our pinball machine's electronic functions will be handled via a microcontroller equipped with a Propeller chip. This is a device similar to the previously-mentioned Arduino, but with greater processing versatility. Furthermore, this assignment emphasizes the development of a skill considered pivotal in the mechatronics field by many academics: the ability to work as part of a group (Acar and Parkin, 1996). By researching theories on mechatronics education and comparing tested methods, I intend to take an even closer look at how building a pinball machine might serve as a solution to bridging the mechatronics interdisciplinary gap. If this project proves to be a successful teaching tool, then perhaps the University of Virginia will have one more tool in their arsenal for building up a full mechatronics engineering curriculum- something I believe is critical to the future success of the engineering school.

STS Topic

While there is extensive research into the impact of action video games on visual attention skills, there is little literature regarding the impact these games might have on auditory attention. Why, you might ask, is this distinction important? As much as we arguably live in a visually-focused world (consider, for example, this paper as a visual medium), our auditory

attention skills are no less important for our success and survival. Rarely does our environment produce only a singular sound at a time. Auditory attention is key for picking relevant information out of the hubbub- identifying it, locating it, and determining a reaction, perhaps in a similar way to how we pick out key details in our field of view. These skills are essential for everyday life, assisting in everything from productivity and task management to safe driving. Whether you are a student focusing on a lecture, a commuter driving to work, a construction worker operating heavy machinery, or a stakeholder in almost any other social or professional group, there is a definite benefit to honing your auditory attention. Despite this, we often let these skills fall to the wayside, favoring the comforting isolation of our headphones. Could video games prove to be an entertaining tool for building these skills back up?

Growing up, so many of us likely heard the same tired line: "video games will rot your brain." However, a series of studies over the past few decades has demonstrated the possibility that video games can hone attention skills. These skill enhancements may not be restricted to the games in which they develop; in a 2017 study by Parong and Mayer, individuals who played a game designed to teach the player to shift between competing tasks showed improved performance on traditional cognitive tests compared to the control group, while other studies showed a notably higher rate of improvement of visual attention skills (Green and Bavelier, 2003) and spatial distribution of attention (Green and Bavelier, 2006) in gamers versus their non-gamer counterparts. Of course, the academic community is not wholly in agreement on the idea that video games improve attention skills (Murphy and Spencer, 2009), but I feel there is more than enough evidence to merit continued investigation. Furthermore, while there is still broad controversy over the claim that video games can cause Attention Deficit Hyperactivity Disorder (ADHD), there is evidence to suggest the contrary; in an experiment comparing gamers

versus non-gamers on their performance on traditional ADHD screening tests, gamers made faster responses and were no less accurate than non-gamers, suggesting that the gamers actually had a better attention capacity (Green and Bavelier, 2012). The way we process sound and sight might be more similar than one might initially think, too; studies across several species have shown that the brain may use similar infrastructure for both sets of attention skills (Fritz et al., 2007). Additionally, if action video games have demonstrated their ability to boost performance on ADHD assessments, is it much of a stretch to consider the possibility that they could also be a training tool for those that struggle with a tendency to "tune out" during conversations or lectures?

Building off of this existing research, I now ask you to consider what elements of design might turn a video game into a tool for improving auditory attention. In their 2020 article, Bradley Kagan refers to games like "Guitar Hero" that focus on playing and recreating music as "musical simulators," and distinguishes them from games that provide greater "musical immersion" (games like "Crypt of the Necrodancer" and "Hollow Knight" that use music and sound cues to convey aspects of the in-game world or experience). While musical simulators are certainly entertaining, I theorize that an immersive experience may be what engages and exercises the attention of the player- providing them with a fictitious sense of consequence, and thus incentivizing success. As one professor of psychology expressed it: "In FPS[2] games, responses to misfortune are always in the nature of "I got killed" rather than "my in-game character was destroyed" (Grimshaw, 2011). Certainly, the gamer still recognizes the difference, and does not truly feel their life is threatened while playing an immersive game, but I believe this observation lends itself to the theory that the brain's attention processing methods might be

[2] "FPS" is an abbreviation of "first-person shooter," a subgenre of action games where the perspective is focused on the character avatar's line of sight, instead of a camera positioned slightly behind the player avatar, as is also common.

shared between virtual and real scenarios. Therefore, we should consider what elements of music and sound design might create an “engageable environment” for the player- not necessarily aiming for realism, but rather, aiming for an environment that a player can comfortably and naturally navigate and absorb through auditory sense. Once we have determined those elements, we can begin to test their effectiveness.

Conclusion

We live in an ever-changing world where we are under pressure to learn new skills and hone old ones. While learning and training can be a wonderful experience, it also has the potential to be immeasurably frustrating, and often we aren’t given the tools we need to succeed. Through exploration of these topics, perhaps we might discover better, more engaging methods of skills development, both for how we actively innovate in the world, and how we passively process that world through our senses. I hope that my thoughts here will help to stimulate further discussion and investigation into the fields of mechatronics education and the use of video games as a training tool for auditory attention.

Citations

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