Embedded System Implementation of Tetris Gaming Console
(Technical Paper)

Evaluation of the societal effects of low-powered, portable gaming platforms
(STS Paper)

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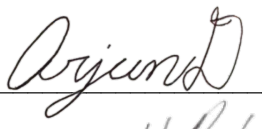
On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature  Date 11/1/2020
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Introduction

Classic arcade games such as *Tetris* (1984) drove the growth of the electronic gaming industry like few other types of video games have before or ever since. However, growing up in the 2000's and 2010's decades was when mobile, portable games were popular. The rise of arcade games as well as the relatively quick change to mobile, portable games was driven by advancements in computing.

With advancements in computer research, computer chips became faster with diminishing power requirements from the 70's to the present such as with the development of MIPS, SPARC, and ARM processors (Hennessy et al., 1982; Garner et al., 1988; Furber et al., 1987). These processor designs are used extensively to power many modern-day embedded systems. Engineers began creating gaming consoles in giant arcade booths, then in moderately-sized gaming consoles users could buy and take home, and finally in cell phones and portable gaming consoles that can be literally carried in your pocket. My capstone group seeks to continue this trend as we create a Tetris gaming console on an embedded system for our 4th year ECE capstone project. Creating a gaming console which uses an embedded system could lead to a significant, new breakthrough in electronic gaming and be the base technology for many new "tech" startups. This also allows the game software to be highly configurable by the user. My specific motivation for this research and choice of capstone project lies in my interests in the fields of embedded systems and computer architecture. My technical research will be centered on my capstone project to create a Tetris gaming console on am embedded system. My STS research will be on the effect of portable, mobile games on mental health of individuals to better analyze the societal effects of my capstone project if it were mass-produced in industry.

Technical Project Details

As an avid video game player and prospective PhD student who hopes to specialize in embedded computer systems and computer architecture, I am always curious to what new, revolutionary breakthroughs will be made at the intersection of these fields. The emerging class of technology known as the "Internet-Of-Things" or IoT consists of small embedded processors connected to sensors or other peripheral electronic devices which can all download/upload information to/from the cloud, internet, or to each other. Many new startups in Silicon Valley today as well as research which goes on in academia serves the purpose of creating smaller, less expensive, and more energy-efficient embedded systems which can address the demands of users for next-generation IoT products. An embedded system is simply a low-power processor connected to other electronic components. Embedded systems are programmed with lightweight software often called firmware or embedded software. While working on an IoT operating system project, I spawned the idea of using an embedded system to run a classic arcade game such as Tetris. Such an embedded system could usher in a new era of electronic gaming where IoT-capable embedded systems could download video game software from the internet in a periodic manner and users could play them with a small controller pad. Embedded software is lightweight (requires little memory to run) enough so that users can program their own game software and run it own their own embedded consoles. As well as adding future ideas for IoT and gaming research, this technical project will also address problems with current industry designs. The problem with many of the current gaming console designs in industry is that they contain electronic hardware which is too expensive (both to manufacture and power) for playing video games with a small memory footprint (small memory footprint of a program indicates that the program does not take up a lot of memory space). An embedded system will force the game

developers to use memory more sparingly.

Previous work has been done in implementing Tetris on FPGA hardware (a type of configurable circuit) and on an AT89S52 Microcontroller which is a type of embedded processor (Liu et al., 2012; Chen et al., 2009). There is also the wide variety of game consoles, computers, phones and digital devices that the Tetris code has been ported to, including Nintendo's Gameboy as a battery powered game console, which loads the game logic and assets from an interchangeable ROM to display on a monochrome LCD display.

My capstone group's work, compared with past published embedded implementations of Tetris, has the advantage of extensible configurability. We plan on implementing scoring/high-score functionality, multiple color display, incoming tetrimino functionality, and pausing functionality. However, our ultimate design will be dynamic in implementation, through judgements made in response to the limitations of working through the COVID-19 pandemic, a smaller time allotment, and a limited budget.

The schedule for completing the desired tasks has our group completing the project before Thanksgiving weekend or the end of on-grounds classes. As of yet, we are currently on track to finishing before this deadline.

STS Topic

It is always appropriate as UVA engineers to evaluate any engineering project from an STS framework before it is created to foresee any effect that could take place if the project was mass-produced in industry. Ideally, this capstone project would inspire many groups in industry or research to produce more video game consoles with embedded systems. However, this leads to questions on how these advancements would impact the daily mental health of society as a whole as well as those individuals which compose it. To do this, I will study the impacts of portable,

mobile electronic games on the mental health of individuals with respect to portable gaming consoles which have already been mass-produced such as cell phone and smartphone games. As anyone might guess portable, mobile games have indeed caused dramatic psychological changes in those who frequently use them (Balakrishnan & Griffiths, 2018). I will study other effects more in depth. My STS research will evaluate how my capstone group's project could change society outside of a traditional engineer's perspective.

There is one group of stakeholders for this research. That is the group in industry such as startup organizations or tech giants who are interested in learning the societal benefits or risks associated with creating mobile, portable, and addictive electronic games. The physical artifacts would be the embedded video game console we build during the semester (completed hardware such as circuitry, microcontroller, and printed circuit board for the capstone project). The non-physical artifacts would include the software developed for the completed capstone project.

This research is important for the following reasons. Moving forward, our lives and especially the lives of younger generations will be controlled by various types of software even more. As video games become smaller and more portable, it is reasonable to assume that the obsession that many users have with these electronic games will only become exacerbated (Heiden et al., 2019). This research will address important questions on whether government should do more of a job in regulating their production so as to protect societal mental health the same way there is discussion on whether the government should regulate social media.

Research Question and Methods

The STS research question I will address is on how advancements in electronic gaming technology such as computer architecture, software engineering, and electronics have affected the collective mental health of society. I will employ the services of the UVA library, google

scholar, as well as the experiences developing my own gaming console for the capstone project is writing my STS research paper as far as the methods are concerned.

Conclusion

The deliverable for my technical research will be my capstone project for the ECE capstone course. That is, it will be a working gaming console running a functional game of Tetris. It will be a mixture of completed hardware and software components interacting with each other to form the gaming console. The deliverable for my STS work would be my completed STS paper on analyzing the effects of video games (especially mobile, portable games) on the mental health and overall psyche of individuals who frequently use them.

My capstone project deliverable, if successful and timely, would fulfill the goal addressed in the technical section of creating one of the first games to be played on an embedded system. My STS deliverable, if completed, would help one understand how such a device might exacerbate the problem of video game addiction.

The anticipated outcome of my technical research is that the capstone project would be completed by Thanksgiving Day and would give me insight on new breakthroughs in game computing. My STS research, I anticipate, would give the department a better understanding on how advancements in gaming have led to a mental health decline for gamers.

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