**SmartSprinter, Perfecting Track Starts**

**Can the Semiconductor Industry Keep Pace with Societal Demand?**

A Thesis Prospectus
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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

Sports are one of the United States' favorite pastimes, bringing together fans from many different lifestyles. For example, an average of 21.4 million people turn on their TVs to watch Sunday night football every weekend (Gough, 2024). Across different sports, speed and agility are often used as important performance points for athletes, whether it is a sprinter running a four-hundred-meter race on the track or a football player executing a forty-yard dash on the field. To improve athletes' performance, sports data and analytics have become invaluable tools, transforming the way teams and individuals approach training and strategy. Sports analytics, an ever expanding field, aims to "to gather and analyze player and team stats," helping the players to "outsmart their opponents and get the winning result" (Srivastava et al., 2021). Using advanced sensors and other innovative technologies, sports analytics aims to turn performance data into a simple quantitative metric. This allows coaches and athletes to specialize and refine their training routines. Our capstone project will be researching, developing and creating a device that uses sports metrics to help runners improve their track starts from a track block.

Previous iterations of similar devices utilized wearable technology and high-quality cameras. Some examples of the wearable smart technology included a "smart" shoe, arm motion detectors, and track sensors that would send pressure and mobility data wirelessly to a cloud database. High resolutions camera would be on the track monitoring the runner for speed and reaction time (Subhashana et al., 2021). The problem with this method is that the device relies on the internet, which isn't always available on a track and field setting, and that the device can impede the sprinter.

SmartSprinter plans to remove these obstacles. First, the device will work independently of wall power or an internet connection. This will allow the device to be used in more situations and in areas that are not as well developed. Second, the device will not impede the runner in any way. Finally, the data provided to runners will be helpful in perfecting a track start. The metrics chosen for this were pressure, height and reaction time. The height and pressure off the block are useful as they are used to maximize horizontal force, which is essential for a superior track start (Čoh et al., 1998).

## Technical Report

The capstone project is split into five subcomponents. They are the central control, height sensing module, start module, pressure module and the laptop graphical user interface (GUI) as shown below in figure 1.

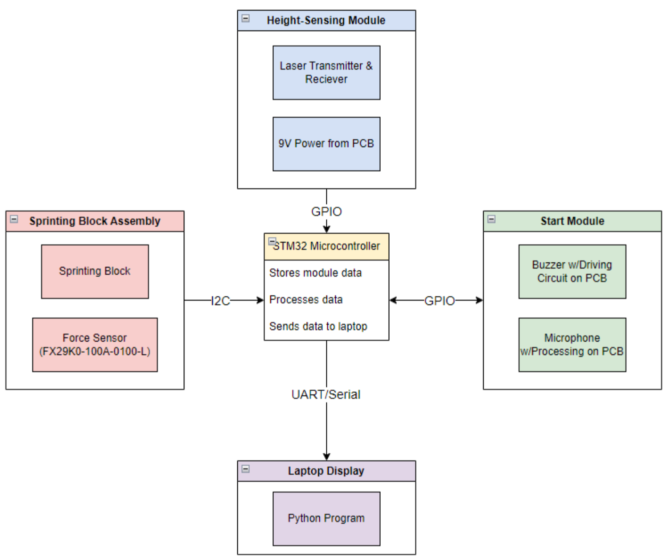


*Figure 1. Block Diagram of SmartSprinter*

The three main subsections that will be used to create SmartSprinter are a track block, a printed circuit board (PCB) and a stand for the height sensors. The track block is purchased online while the printed circuit board and the height stand will be created by my capstone group. Communication between the different modules will be either general pin high low (GPIO), $I^2C$ protocol, or universal asynchronous receive transmit (UART) protocol. The $I^2C$ protocol from the force sensor to the central control will follow the UM10204 standard of $I^2C$ communication (NXP Semiconductors, 2021). In addition, UART will follow the TIA/EIA-232-F and RS-485 standards for the communication between the central control module and the laptop (Texas Instruments, 2002; Thomas Kugelstadt, 2008).

The control module is comprised of a STM32 microcontroller (STMicroelectronics, 2024). It will be the device that gives command to each of the PCB modules to start and when to send their gathered data. This microcontroller is a single core device, meaning that it can only perform one action at a time. This means that some delay will be present as we cannot grab all the information required from each module simultaneously.

The PCB will contain the start module, the pressure module and the height module driver circuits. First, the start module will have the ability to trigger the start or detect a start from a track gun. This is done by using a speaker and microphone with auxiliary circuits to either detect audio beeps or generate a noise. The pressure module will be a single FX29 pressure sensor embedded into both of the track block pedals (TE Connectivity, 2020). Pressure data will be grabbed for a period of six seconds and displayed by a graph in the GUI. In addition, pressure data will be used with the start module to calculate the reaction time of the runner. This will be done setting a pressure threshold and finding the time difference between the runner hitting the pressure threshold from the detected start time. The height module drivers will be situated on the PCB while the height sensor will be at the side of the track. Finally, the PCB itself will be situated on the back of the track block and will data packets to the laptop GUI through a UART cable.

By making our device run through solid wires and be powered by multiple AA batteries, the device passes goal one. Goal two is completed as the device is only situated on the track block and on the edges of the track. This allows the sprinter to practice unimpeded by our device.

In conclusion, our device passes goals three as horizontal force, through the height module and pressure sensing, and reaction time, through the start module and pressure sensing, is completed.

**STS Report**

In November, 2024, Nvidia replaced Intel on the Dow Jones stock index (*Nvidia Replaces Intel on the Dow*, 2024). Nvidia stock rose by over three hundred percent while Intel fell fifty percent in the last three years (*NVDA vs INTC Stock*, 2024). Nvidia is a company that mainly produces graphical processing units (GPUs) for desktops while Intel is a company that mainly produces computer processing units (CPUs). With the boom of artificial intelligence (AI), GPUs are becoming more and more useful than CPUs as they are better at processing AI's needs.

Semiconductors are the major component used with GPUs, but traditional methods of increasing performance are starting to become obsolete. In the April, 1965 addition of *Electronics Magazine*, Gordon E. Moore made the speculation the density of silicon components on a chip would double every eighteen months (Schaller, 1997). This was the common method for performance increases until the early 2010s. But around 2016, massive increases in semiconductor density were no longer possible at the rate Moore predicted. It took five years for Intel to get from fourteen nanometer semiconductor technology to ten nanometer technology (Woods, n.d.). In addition, the modern three nanometer creation process is not actually creating a three cubic nanometer semiconductor, rather just improvements in optimizations in semiconductor creation. For it to be actually three nanometers in length, a silicon transistor can only be about fifteen silicon atoms in length (Traverso, 2024). This size is impossible to work at because classical physics begins to interfere. So how has Nvidia, and other electrical component companies, been able to keep outputting devices that increase in performance every two years? Will these companies keep on pace with societal demand for more powerful electrical components?

I plan on answering this question using Hughes' technological momentum theory produced in his essay *The Evolution of Large Technological Systems*. In his essay, Hughes mentions how system builders integrate diverse components to overcome technological and societal challenges with reverse salients being components or subsystems that hold back the development of technology. Hughes also goes over different stages of development, with the innovation stage being the adaption of a system to society (Hughes & Bijker, 1987). I plan to look at publicly available data on GPU performance over the last two decades and see what modern semiconductor creation processes are being used to overcome density issues and its effectiveness on performance. This data will show whether electrical components will stay within its innovation stage of life or move on to later stages, such as decline or transformation. Will the new processes have enough momentum to by new system builders or will semiconductor density be too strong of a reverse salient for future societal demand?

**Research and Methodologies**

With the end of traditional methods of performance increase compared to societal demand, a problem forms. Can industry find new methods of semiconductor production to keep pace with performance demand?

I plan to research this topic using publicly available data on GPU performance from *Tom's Hardware* website and cross-refence performance improvements using methodologies used by industry. I will find the topologies used for newer GPUs from manufacturers', such as Nvidia or Advanced Micro Devices (AMD), releases and find more in-depth details on the manufacturing process in publications on research websites such as *IEE Xplore*.

By combining these two data sets, I plan to find out if industry can keep pace in future electrical component performance improvement when compared to the past. With this data, I will show whether the semiconductor industry can stay within its innovation phase of technological momentum for societal demand or if future technologies will be impacted.

**Conclusion**

In sports, athletes are always trying to find a way to get an edge above their competition. SmartSprinter will give them a way for athletes to train their sprinting starts that is closer to competition with qualitative metrics that can be seen to increase or decrease over time.

With the end of semiconductor density being the major form of improvement for electrical components performance, the industry will have to change. Will it be able to keep the same pace of improvement for other societal demand, such as processing for AIs, or will it fail to increase at the same speed?

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