Thesis Project Portfolio

Autonomous Chess Robot

Technical Report

The Semiconductor Industry

STS Research Paper

An Undergraduate Thesis

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Technical Project

The technical project portion of this portfolio is a robotic system capable of autonomously playing chess against a human opponent. The key components of the system are a gantry-based structure for retrieving and moving chess pieces around the board, a Raspberry Pi 3 Model A+ (Raspberry Pi) on which runs an open-source chess engine, an MSP432E401Y (MSP432) microcontroller that orchestrates the system, and a custom-designed printed circuit board (PCB) for routing power/data and providing a hardware interface to the player. The system uses a network of reed switches, electromechanical devices that close in the presence of a magnet, (called the "sensor network") embedded below each tile on the chess board to detect the presence of pieces. In conjunction with a memory-managed record of the board state, kept since the beginning of the game, this allows the robot to identify which pieces are located in which tiles at any point in time, the "board state". Each time the human makes a move, the system scans the sensor network to determine the current board state. This is compared to the previous board state to determine the move that was made, which is then transmitted to our chess engine of choice, Stockfish, over a Universal Asynchronous Receiver/Transmitter (UART) data bus. Stockfish responds with a move for the robot to make, which is then performed as a series of motor commands on the MSP432. The notion of this chess robot extends the human condition in that it puts a technological spin on a game traditionally focused on human interaction and competition. That is, it lays a framework of possibilities for the design of autonomous systems that can be expanded upon for generations to come.

STS Paper

The sociotechnical thesis portion of this portfolio focuses on the Semiconductor Industry and uses an Actor-Network Theory to analyze the supply chain as well as going in depth on the history of the semiconductor industry and how the industry has changed over the years. This paper is a compilation of literary analysis in that only previous works are discussed. The relationships between the economics, geopolitics, and technological advancements are explored through research of history and current policy of the United States and other governments.

The main motivation for this research was the introduction of The Chips and Science Act passed by congress in August of 2022. This bill is a statement on how the US government sees the importance of semiconductors of late and how they would like to see the market, specifically the chip manufacturing market, change in favor of the US. This development and change of opinion from congress can be highlighted by the chip shortage following the years of the Covid-19 pandemic. The exact reasons for the shortage are nuanced, but mainly sum up to supply and demand issues. When chip purchasers expected a decrease in their product demand, they purchased less chips, and so in response, chip manufacturers reallocated their production to other lines. So when chip consumers needed more chips sooner than expected, their manufacturers had already moved on to other buyers, the other consumers had to delay their own product lines.

Through research, it was found that the industry has many choke points, in that even though the industry has reached a global scale, only a few companies dominate critical points of the chip process. For example, ASML (Advanced Semiconductor Materials Lithography) and TSMC (Taiwan Semiconductor Manufacturing Company) are two companies that have grown to dominate their portion of the semiconductor industry. ASML manufacturers high end lithography machines, including EUV (Extreme Ultraviolet) and DUV (Deep Ultraviolet). ASML is the only

company that manufactures EUV machines at the time of writing, and so in order to manufacture the highest quality chips, one must purchase machines from ASML. TSMC, like ASML, is another choke point in the supply chain. They are not the only manufacturer of semiconductor chips, but they do dominate the market.

In this paper, another goal was to examine the role of the US military in the semiconductor industry as well. This was done through research of the military's historical role in purchasing semiconductor products during the Cold War and how funds from that era really sparked the need and funding for integrated circuits. The technological accuracy and advantage that integrated circuits brought the US did incite fear into the USSR. The USSR knew that in order to keep up with the US, they needed the accuracy that higher computing power provided. The USSR ultimately could not keep up with the US in that their strategy was to copy the US and hence was always behind. China, on the other hand, has also become an economic and geopolitical powerhouse. China is aware of the fact that they have been wholly dependent on their geopolitical rivals for high end chips. In response, China has begun investing in their own semiconductor industry and making sure they have a domestic supply of high-end technology, to the extent that they have stolen IP (intellectual property) from multiple companies.