

Creating an Autonomous Chess Robot

Comparing Child Development in Urban and Rural Areas of the U.S.

A Thesis Prospectus
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By
Keenan Alchaar

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Technical Team Members:
Nick Cooney, Eli Jelesko, Gabriela Portillo

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.

ADVISORS

Joshua Earle, Department of Engineering and Society

Harry C. Powell, Department of Electrical and Computer Engineering

Introduction

Automation has been a hallmark of the industrial era, from manufacturing to transportation. However, one area where automation receives less consideration is physical games (as opposed to online games). So, the technical project at hand is an autonomous, intelligent robot that plays chess, over the board, against one other human player. With this, I pose the question: **How can physical automation and artificial intelligence benefit chess players?**

Though not quite as concrete as the technologies we rely upon every day, the contexts we live in (i.e., rural, suburban, urban) often significantly impact what resources are available to us and how our daily life looks. There are many ways to define “urban” and “rural,” but one way to interpret a rural area is an area that is “relatively sparsely settled with small populations and relatively isolated from large cities” (Clark et al., 2022). From here, I wondered how this difference may affect child development, which is the primary focus of my STS paper. So, I pose the following question: **How does child development differ between rural and urban areas in the United States?** Secondly, I want to define what aspects of these areas, whether technology or public policy, give rise to these differences and provide solutions for negative differences. Clark et al. explain why understanding this divide is important: “growing up in rural areas matters not only for children’s development and well-being, but also for their future life chances” (Clark et al., 2022).

Given the greater degree of isolation present in rural communities, many of these children may not have as many opportunities to play board games with their peers outside of school. Distant peers may require a car to visit each other, and one may not always be available. Our technical project offers a potential solution that, via automation, allows children to play over-the-

board chess without peers. The STS research will answer which specific benefits we can or cannot expect game automation to bring to rural communities, given their current state of affairs.

Technical Project: Creating an Autonomous Chess Robot

Motivation

In the 21st century, and especially when the COVID-19 pandemic began, many people found themselves playing multi-player games online, whether with friends or strangers. Chess saw a similar phenomenon. In April 2020, the online chess website Chess.com gained 1.5 million new subscribers compared to 670,000 in January 2020 (LoRé, 2020). However, the short-wavelength blue light emanating from these screens has been shown to cause diseases such as dry eye and inhibit melatonin secretion, leading to a reduction in sleep quality (Zhao et al., 2018). Moreover, my capstone team and I wanted to consider people who preferred over-the-board chess to online chess when possible. Over-the-board chess incorporates more visual and tactile components, such as reading one's opponent, interpreting the board in 3 dimensions, and moving pieces with one's hands. The additional information processing required should provide good practice for over-the-board chess tournaments.

Technical Brief

The goal of this technical project is to create an autonomous, robotic system fully capable of playing chess against one other human player. We will achieve this by selecting appropriate hardware to move pieces across the chess board. Then, we will implement software to control the hardware and give it intelligence via a chess engine. The entire system consists of five

subsystems: A gantry system, a sensor network, an MSP432E401Y (MSP432) microcontroller, a Raspberry Pi 3 Model A+ (Raspberry Pi), and a printed circuit board (PCB).

The gantry system allows the robot to move pieces around. It consists of multiple bars of extruded aluminum and three stepper motors. Two of the stepper motors provide dual-axis motion above the chess board, while the third stepper motor lifts and lowers an electromagnet. The electromagnet is responsible for “grabbing” pieces via magnetic screws drilled into them.

The sensor network allows the robot to read the board and determine piece positions. It consists of 64 reed switches beneath the board, which will tell the microcontroller where the pieces are since the pieces will also be magnetized on the bottom. Although these switches do not uniquely identify pieces, this will not be necessary, assuming the game begins from a known state and can be tracked one move at a time thereon.

The MSP432 and Raspberry Pi perform different tasks, but together, they form the software backbone of the system. The MSP432 microcontroller is responsible for processing data received from the sensor networks and sending it to the Raspberry Pi computer using Universal Asynchronous Receiver Transmitter (UART). UART is a serial communication protocol that allows the MSP432 and Raspberry Pi to exchange messages with one another. The Raspberry Pi will use a software library known as python-chess to process the move and determine its legality. If the move was legal and did not end the game, the chess engine Stockfish will generate a logical move for the robot to make, and the Raspberry Pi will send it to the MSP432 over UART. The MSP432 will then control the gantry system through the motors, making the desired move. This exchange between the human and robot’s turns will continue until checkmate or stalemate has been reached.

Finally, the PCB will route power from a 120V power supply to the sensor network, electromagnet, and motors via 24V, 5V, and 3.3V rails. It will also route data from the sensor network to the MSP432. Additionally, it will provide a hardware interface including an “emergency stop” button to halt all system activity, a toggle switch to set the player’s color (white or black), a “start” or “reset” button to initiate or reset the game, and a “next turn” button to end the human’s turn.

STS Project: Comparing Child Development in Urban and Rural Areas of the U.S.

The Primary Research Question

I will not be examining one specific technology but rather distinct characteristics of rural and urban communities which give rise to their differences regarding child development. Once again, my research question will be: **How does child development differ between rural and urban areas in the United States?** I have deemed this question important because preliminary research has shown a child’s community can affect their development, well-being, and future life chances. But why? Can either urban or rural communities learn from each other to improve the negative aspects of child development in each?

Social Groups of Interest

One social group that shares a similar scope with rural and urban communities is suburban communities. While I could meaningfully analyze them alongside rural and urban communities as past literature often has done, I believe I can achieve greater depth and insight by focusing on the most disparate communities, i.e., rural and urban communities.

I will focus on rural and urban communities *in the United States* to further narrow the scope and strive for depth. These communities can be anywhere in the continental U.S. (this excludes Hawaii and Alaska). “Communities” will include children *and* adults, as I believe adults are still influential in forming the context in which children live. Nonetheless, children’s development and outcomes will be the primary focus. Based on past literature, there is no authoritative definition of how to differentiate between rural and urban communities. However, I believe there are stark enough differences between these contexts that would allow for flexibility when consulting past literature. So, I will not restrict myself to any one definition of urban and rural for this paper. When researching urban and rural communities, I intend to include anyone past research has included. As I will discuss in the “Key Texts” section, past research has studied a variety of rural and urban children of different races, family statuses, ages, and income levels, among other differentiators. I will note where appropriate when the author has not controlled for such variables and consider this when drawing my conclusions.

Key Methods and Frameworks

To understand *why* child development may differ between urban and rural communities, I will use actor-network theory to define and relate the various factors that affect a child’s upbringing. I will then locate points in the network that may be ultimately responsible for any common differences past literature has found between rural and urban children. Understanding the actors that influence a child’s life will also allow me to suggest what would improve a child’s quality of life in a rural or urban context.

Before writing this paper, I plan on consulting past literature to understand the current state of affairs concerning child development between rural and urban areas. With this insight, I

intend to complete two tasks. First, I will construct an argument that directly addresses key differences between child development in rural and urban areas. Second, I will create an actor-network map to determine how power flows between actors and if the most powerful among them could alleviate problems within rural or urban areas. This timeline should allow me to answer my research question and determine who can likely improve child development in rural or urban communities.

Key Texts

One article in the *Journal of Rural Health* includes statistics about child poverty ($n = 3142$) between rural and urban contexts. It also includes other insights, such as uniquely rural risk factors and the use of health services (Probst, 2018). This article ends with suggestions on how to improve rural communities, which I can synthesize with my research to conclude who or what can feasibly improve them.

Another journal article, “Growing Up in Rural America,” studies the various advantages and disadvantages of growing up in rural America. In particular, it argues “growing up in rural America offers distinctive advantages and disadvantages, yet the benefits may accrue primarily to those who leave” (Clark et al., 2022). This could have interesting implications for an actor-network analysis. This source could clarify what actors appear or disappear upon leaving rural areas and the implications of this change in the network.

“America’s Forgotten Children” is a report that “draws on research, statistics, and the voices of rural young people to document the extent and causes of rural child poverty” (Nadel & Sagawa, 2002). This source, in particular, includes stories as told by older rural children. This

source will provide useful variety since stories can provide a more varied, nuanced perspective than raw statistics may.

Finally, the paper “Poverty, Urbanicity, and Children’s Development of Early Academic Skills” explains how “the experiences and repercussions of poverty may differ based on the macrosystem in which poverty occurs (Votruba et al., 2015). This source will help me compare how children experience poverty differently in rural and urban communities.

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