Computer Assisted Gomoku Board

ECE 445 Project Proposal
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1. Introduction

1.1 Objective

Gomoku is a strategy board game and requires a lot of moves. Our goal is to build a computer assisted Gomoku board which is able to simulate the on-board play automatically and simultaneously, and to project the simulation onto a screen. Often during practicing, players have to record the whole game move by move manually on a piece of paper so that they can later analyze their games. However, this way of recording not only distracts players during their games, but also is quite inefficient and tedious. Other than the negative influence on players, current technology of broadcasting Gomoku games is still outdated. The current method which medias adopt to stream Gomoku games is to manually put Go pieces on the Go board to simulate the actual game. In this way, for both players and viewers, replay of the game is inconvenient and not efficient enough. Gomoku has world championships every two years and is developing into a more popular and world-wide abstract strategy board game [1]. The current technology is not sufficient to support the growing need for efficient broadcasting and game replay.

We will use an array of pressure sensors in the design to achieve the automation of the board. The standard Go board uses 15×15 of the 19×19 grid intersections [2]. In order to simplify and increase the fluency of the design, we will make a board with 10×10 grid intersections instead. We will adopt an appropriate microprocessor to collect data from pressure sensors, analysis data and send signals to projected screen through a bluetooth device.

1.2 Background

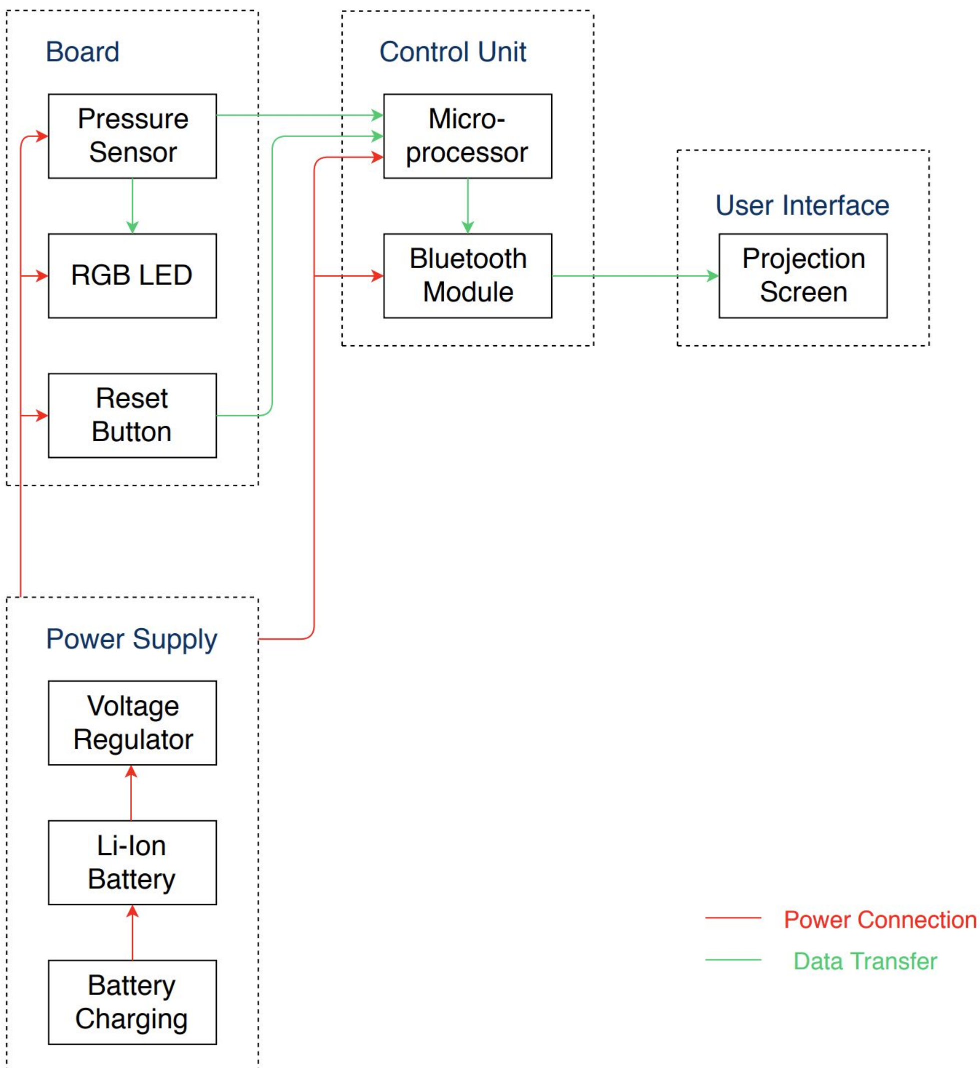
Computer usage has been associated with Gomoku for decades. Artificial intelligence specialized of play Gomoku games has been created. In Gomoku World Championship (GWC) 2017, Yixin had a 2-game match with Rudolf Dupszki, the champion of GWC 2015 [3]. Yixin is a program created to play Gomoku. However, there has not been a similar product designed for easier broadcast of Gomoku games. With similar working theory, we also expect the design can be applied to other board games such as chess and I-go.

1.3 High-level Requirements List

- Our board should be able to detect a piece being put onto the board, and accurately report which cell the piece is put in with a successful rate of 95%.
- When a game is over, the microprocessor should detect it and send a signal to the computer, which would automatically save the whole game.
- The program on the computer should be able to load a previously saved game and let us replay the game step by step.

2. Design

2.1 Block Diagram



The Board Block consists of 100 force-sensitive resistors, two RGB LEDs, and reset buttons. The data collected by the sensors will be sent to the Control Block, and processed by the microprocessor. If the microprocessor detects a change of the game state, it will send the data to PC Program(User Interface Block), via Bluetooth Module. The Power Supply Block supplies power to Board Block and Control Unit Block.

2.2 Physical Design

Concerning both practicability and nice-looking of the final product, we expect to design the board as a box, with the checkerboard on the top. Pressure sensors would be set up on the second layer. Batteries, microprocessors and Bluetooth module should go under the pressure sensors. With this design, the product should be like a normal Gomoku board only with larger thickness.

2.3 Functional Overview

- Power Supply

  Power Supply Block will be consists of three parts: Battery Charging Module, Li-Ion Battery, and a Voltage Regulator. This module will supply power to the pressure sensors and LEDs on the board, and will power the control unit including the microprocessor and bluetooth module.

- Board

  Board Block will be consists of 100 Force-sensitive Resistors (FSR402), two RGB LEDs, and Reset Buttons. Since our board has 10 x 10 intersections, we need one FSR for each of the intersections. The 100 FSRs will be connected to multiplexer circuits, which would then send signals to Control Unit Block. Two RGB LEDs are needed in our Board Block. LED1 is Bluetooth Connection Indicator. If the Bluetooth is connected to the PC Program, LED1 will be Green, and if else, Red. LED2 is a move indicator. If the Control Unit successfully detects a piece is put onto the board, LED2 would blink Green. If a move is undone (controlled by the Undo Button), LED2 would blink Red.

- Control Unit

  Control Unit Block will be consists of a microprocessor and a Bluetooth Module. The microprocessor needs to take inputs from the Force-sensitive resistors and determine whether and where a piece is put onto the board. It also has to detect whether one of the Reset Button or the Undo Button is pushed. The microprocessor needs to keep track of the current game state, and send new game state to Bluetooth Module, if the game state is changed. It also has to control LED2. A Bluetooth Module is needed to take the current game state as input from the microprocessor, and send the game state to User Interface Block, which is a PC Program. The Bluetooth Module is also connected to LED1.

- User Interface
  User Interface Block will be consists of a PC Program. The program needs to receive data from the Bluetooth Module in the Control Unit Block. Whenever a piece is put on the board, the PC program should receive the data via Bluetooth and display the game board on the computer screen.
  If the game is ended, the PC program should receive a signal via Bluetooth, and display the winner on the screen. If the game state is changed by the Reset Button or the Undo Button, the PC program should also reflect the change on the screen.

2.4 Block Requirements

2.4.1 Power Supply

- Li-ion Battery
  We plan to equip the 3.7V Lithium-Ion Battery Rechargeable (Secondary) 2.6Ah to power the system. We choose this type because it is easy to get at low cost and would be a sufficient power supply for the system.
  Requirement 1: Able to support the system long enough for at least an hour.
  Requirement 2: Able to stay functional under low temperature.

- Battery Charging Module
  We choose the 4-Bay T4s Intelligent Universal Charger from Tenergy as our first choice. This charger can charge four Li-ion batteries at the same time. And with signal LEDs on it, WE can know the states of Li-ion batteries on time.
  Requirement 1: Reverse polarity protection.
  Requirement 2: Automatically stops charging when complete.
  Requirement 3: Designed for optimal heat dissipation.

- Voltage Regulator
  The AZ1117E voltage regulator can take maximum input voltage of 13V and output at 3.3 V. The AZ1117E has been optimized for low voltage where transient response and minimum input voltage are critical. It provides current limit and thermal shutdown protection solutions.
  Requirement 1: Must provide output voltage at 3.3V +/- 5% for stable supply.
  Requirement 2: Low output noise.

2.4.2 Board

- Force-sensitive Resistors Array

We choose to use FSR402 sensor, for its technical features best match our requirements. With a 18mm diameter, it is about the same size as each cell of the board. Also, its actuation force is 0.1N, far more less than the force players apply on the board while placing a piece (usually around 0.5N). Other features, such as sensitivity range, thickness, and operating temperature, also meets our expectation. [4]
Requirement 1: Actuation force less than 0.2N.
Requirement 2: Sensor diameter less than 20mm.
Requirement 3: Active sensing area more than 10mm.
Requirement 4: Fully function at room temperature with long enough life time.

- RGB LEDs
  The LEDs should receive signals from the control unit to blink green or red with each corresponding situation.
  Requirement 1: At least two color channel.
  Requirement 2: 20mA operating current.

- Buttons
  2 standard pressable buttons are used to reset the game and undo previous move.
  Requirement 1: Pressable and durable.

2.4.3 Control Unit

- Bluetooth Module
  A HC-06 Bluetooth Serial Pass-Through Module will be used for the microprocessor to both send or receive the TTL data from the computer. With coverage up to 30 feet, a standard bluetooth 2.0 data transmitting speed, and the small size, the HC-06 module is suitable for this project. [5]
  Requirement 1: Data transmitting latency within 0.2s.
  Requirement 2: Coverage at least 15 feet.
  Requirement 3: Operating voltage at 3.3V.

- Microprocessor
  We plan to use ATMega328P microprocessor [6]. It has 32KB flash memory, and 2KB SRAM. This is a commonly used microprocessor, with operating voltage range of 1.8V to 5.5V, and considerably good computing ability.
  Requirement 1: The microprocessor must take inputs from all the force sensors.
  Requirement 2: The microprocessor must be able to store the program.
  Requirement 3: The microprocessor must be able to determine which cell the piece is put in in 0.3sec.

2.4.4 User Interface

- PC Program

  We will write a PC Program that runs on a PC, and connects to our board via Bluetooth. The program should display the board on the screen.
  Requirement 1: The latency of receiving data should be less than 0.5 sec.
  Requirement 2: The screen should be updated if a piece is put on the board.
  Requirement 3: The screen should be updated if Undo Button is hit.
  Requirement 4: The screen should be updated if Reset Button is hit.
  Requirement 5: The program should display the winner (or tie) if a game is ended.
  Requirement 6: The program should be able to save each game.
  Requirement 7: The program should be able to reload a game and replay it step by step.

2.5 Risk Analysis

The block that poses greatest risk to successful completion of the project is the Board Block. Since there are 100 force sensors, we will need to implement a large scale circuit to process and cascade the force sensors' signals. This circuit will be very complicated and prone to bugs. Furthermore, our project is relying on perfect operation of the 100 force sensors. If any of the force sensors is broken or malfunctioning, the board would be unsuitable for playing games.

3. Ethics and Safety

Ethics and safety are vital factors to consider in our senior design. Specifically discussing ethical concerns, we will divide the discussion into three parts. As for the general ethical principles, we would abide strictly according to #1.2 and #1.3 of ACM Code of Ethics and Professional Conduct to avoid harm and stay honest and trustworthy during the design process. We would be clear on the qualifications and be honest with the limitation of our project [7]. Next, considering the professional responsibilities, we would attempt for highest quality on both the design process and final product of the project. We would be willing to seek and accept criticism, to understand, acknowledge and correct mistakes, and to credit properly to all contributors [8]. Furthermore, professional leadership principles are also significant in our senior design project. As a group of three members, each of our group members would do the utmost to contribute to the progress of the project. We would seek and respect every member's idea and strive to put thought into reality.

Other than ethics, safety is also a significant concern. Our project comes with some safety hazard which requires our attention. Lithium-ion cell becomes thermally unstable at 150°C, a condition that can lead to a thermal runaway in which flaming gases are vented [9]. Batteries should never rise above 130°C. Another safety issue with Li-ion batteries is charging under low temperature. Consumer-grade Li-ion batteries cannot be charged under 0°C, an situation which can do permanent damage to batteries and make them more vulnerable.

As a circuit with 64 pressure sensors, the whole project can be malfunctioning with only one sensor out of order. And short pass of a single sensor may damage the circuit and cause safety hazard. We must ensure all sensors are connected properly with suitable voltages and current drawing.

References

[1] Gomoku World, ‘World Championships - History’, 2018. [Online]. Available: http://gomokuworld.com/worldchampionship/6. [Accessed: 18 - Sep - 2018].

[2] Allis, L. V.; van der Meulen, M.; and van den Herik, H. J. "Proof-Number Search." *Artificial Intelligence* **66**, 91-124, 1994. Available: http://mathworld.wolfram.com/Gomoku.html. [Accessed: 18 - Sep - 2018].

[3] AI EXP, Kai Sun, ‘Rudolf Dupszki versus Yixin’, 2017-7-23. [Online]. Available: http://www.aiexp.info/ai-vs-human-gomoku-2.html. [Accessed: 20 - Sep - 2018].

[4] InterLink Electronics. Available: http://www.trossenrobotics.com/productdocs/2010-10-26-datasheet-fsr402-layout2.pdf.

[5] Guangzhou HC Information Technology Co., Ltd. Available: https://www.olimex.com/Products/Components/RF/BLUETOOTH-SERIAL-HC-06/resources/hc06.pdf.

[6] Microchip, ‘ATmega328P’. Available: https://www.microchip.com/wwwproducts/en/ATmega328P. [Accessed: 20 - Sep - 2018].

[7] Association for Computing Machinery, ‘ACM Code of Ethics and Professional Conduct’, 2018. [Online]. Available: https://www.acm.org/code-of-ethics.[Accessed: 20 - Sep - 2018].

[8] IEEE.org, ‘IEEE Code of Ethics’, 2018. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 20 - Sep -2018].

[9] Battery University, ‘Lithium-ion Safety Concerns’, 2010. [Online]. Available: https://batteryuniversity.com/learn/archive/lithium_ion_safety_concerns. [Accessed: 20 - Sep - 2018].