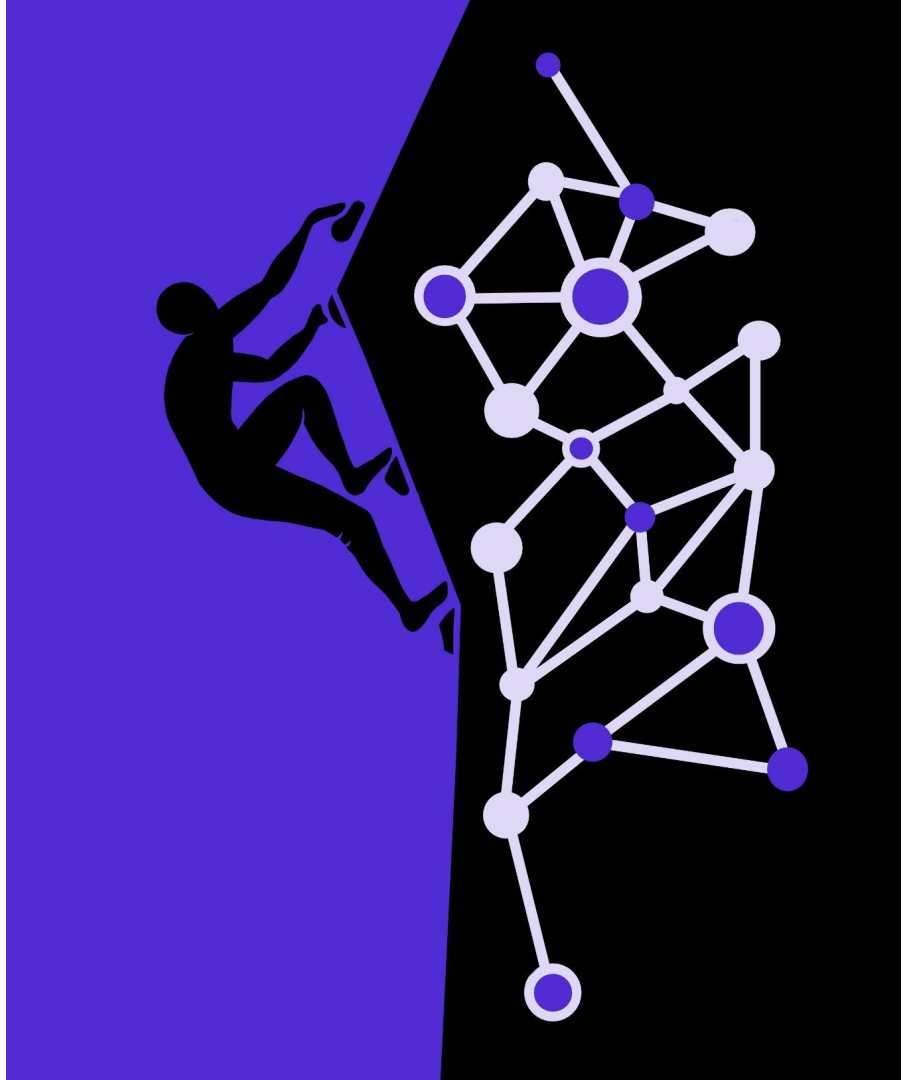
Bouldering Path-Finding

Team: Ethan Reed, Tristan Pommering, Oankar Santosh Ghorpade, and Bridget Hoernschemeyer

Project Advisor: Professor Gallagher



Goals

The primary goal of this application is to provide personalized climbing routes based on user-specific factors. This allows for beginner boulderers to improve their climbing technique by following optimized paths tailored to them.

Additionally, the project seeks to enhance the climbing experience through an intuitive and user-friendly interface, making climbing more accessible and enjoyable for all.

Intellectual Merits

For the pathfinding algorithm, we are expanding on the A* algorithm to find the best route to the goal node based on a user's entered height, wingspan, and ranking of bouldering hold types.

By implementing heuristic-based pathfinding for each limb, this approach ensures that the suggested routes are both efficient and practical, enhancing the applicability of AI-driven pathfinding in real-world climbing scenarios.

HOW OPTIMAL PATHS ARE GENERATED

1. USER PROFILE DATA

Users can enter their data under the profile section, which is used to individualize routes. This includes height, wingspan, difficulty level, and desired hold type rankings.

2. DETECTING HOLDS

After uploading images, users are prompted to select the color of the holds corresponding to the route they want to generate a path for.

3. HOLD ANNOTATION

Users are given the option to edit the detected holds. This includes assigning hold types and selecting start and end holds.

4. CUSTOM A* ALGORITHM

Hold annotations and user data are sent to the pathfinding algorithm, which searches for an optimal path using every limb.

Broader Impacts

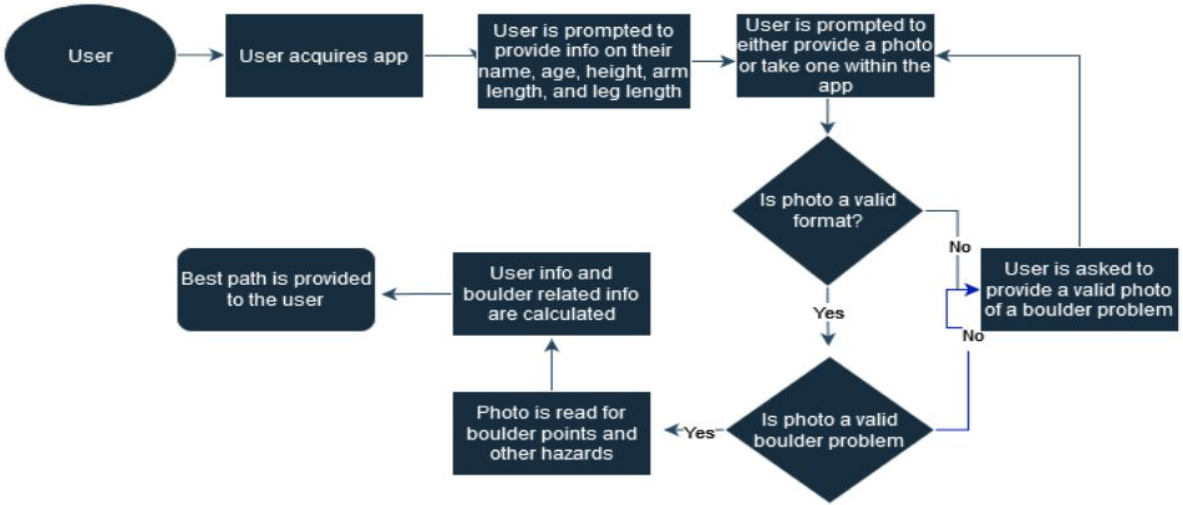
This project has the potential to make bouldering more accessible and engaging for a broad range of climbers. By providing personalized climbing routes, it lowers the barrier to entry for newcomers, allowing them to improve their technique with tailored guidance. Additionally, it enables beginner and intermediate climbers to refine their skills by identifying more efficient and optimized routes.

Design Specifications: System Overview

- Platform: Android
- Purpose: Optimize climbing routes for uses based on profile data and picture of bouldering problem
- Technology:
  - Pathfinding AI
  - Blob Detection
- Expected Output: Simple and easy to read path from start to finish presented in a step by step fashion.

Design Specifications: Design Diagram

The user must acquire the app on its proper app store (android). The user must update their profile with their height, wingspan, and skill level. Then the user can provide a photo of the desired bouldering problem. Once the photo is validated and proper start and finish is provided the pathfinding AI will generate a path. Using all the info the user provided a optimal path for that user is generated and presented in a step by step manor.



Technologies

- Pathfinding AI: A* pathfinding
- Blob Detection: EMGU CV: OpenCV
- Framework: .NET Multi-Platform App UI (MAUI)
- Language: C#

The project is entirely written in C#. The app is built only to work on Android devices. We use OpenCV to identify where the holds are on a given image as well as their desired color. A* pathfinding is used with heuristics based on the users profile data to generate the path. All other UI and visualization is created using .NET MAUI tools.

Milestones

- **October 2024:**
  - App creation
  - Environment setup
  - User Profile setup
- **November:**
  - Added ability to load images from gallery
  - Added ability to take a photo within the app
- **December 2024:**
  - Using blob detection to identify all holds in the photo
- **January 2025:**
  - Added feature to allow user to identify all holds of a specific color
  - Added optional feature for the user modify identified holds to be a specific hold type
  - Added ability for user to identify the starting point and the end goal
  - Added optional feature to allow user to create multi limb start/finish
- **February 2025:**
  - Created a path using the above information and displayed it to the user

Results

- Completed:
  - App loads a picture from gallery or camera
  - Blob detection can recognize desired objects in the photo by color
  - User profile
- In Progress
  - 90%: User modifying holds
    - All desired multi limb start/finish option: Mid February
    - Make page more readable: Early March
  - 50%: Pathfinding
    - Generate pathfinding for all limbs: Late February
    - Generate step by step display for user to follow: Early March
  - 30%:UI and QOL features
    - Low priority: We need to modify the UI to be more user friendly: Mid March
    - Low priority: Some quality of life features not required or expected for demo: Late March

Challenges

- Blob Detection
  - The first main challenge we faced was how to identify the rocks by color as well as what type of hold they are. We were running into issues where open source tools wouldn't work on Android or didn't do what we specifically needed.
  - We solved this by finding a Lite version of OpenCV that has android runtime and allowed us to identify things by their color. We thought adding hold types would be too advanced and inaccurate so we decided to let the user optionally modify identified holds to be easy (jugs), medium (Crimps), Hard (Sloper or Pinch)
- Path finding
  - We wanted to use evolutionary computing to generate multiple paths and allow the user to select the one most suited for them but quickly determined that time and limited computing on mobile devices would create issue so we settled on the simplest pathfinding that would work for us which is A*
- Display an UI
  - We need to figure out a UI design to make the app feel more seamless and readable.
  - We also have the issue of trying to display the route to the top showing where both your hands and feet go can look cluttered and difficult to read or memorize if needed to be used. The solution to this problem is to display everything in a step by step way indicating which hand/foot goes where 1 step at a time.