Bouldering Path Finding

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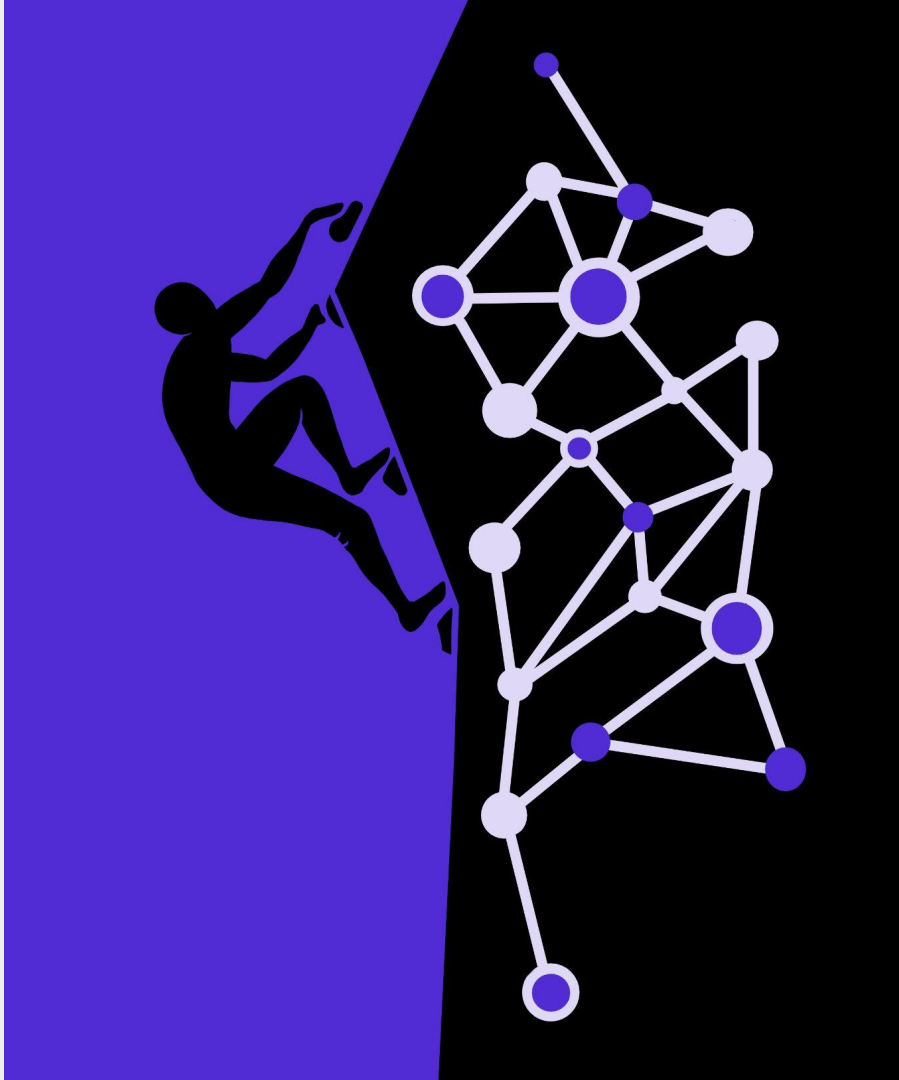


Goals

- 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.

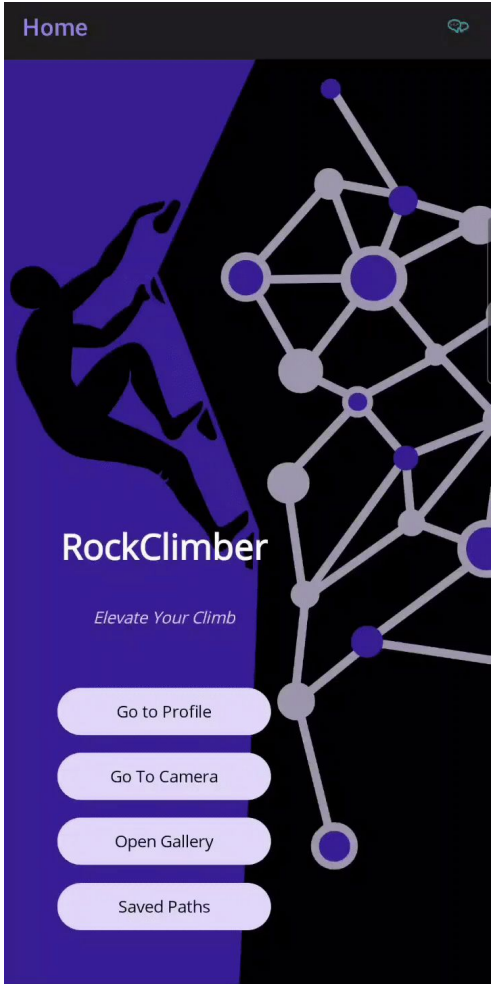
Broader Impacts

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.

Profile

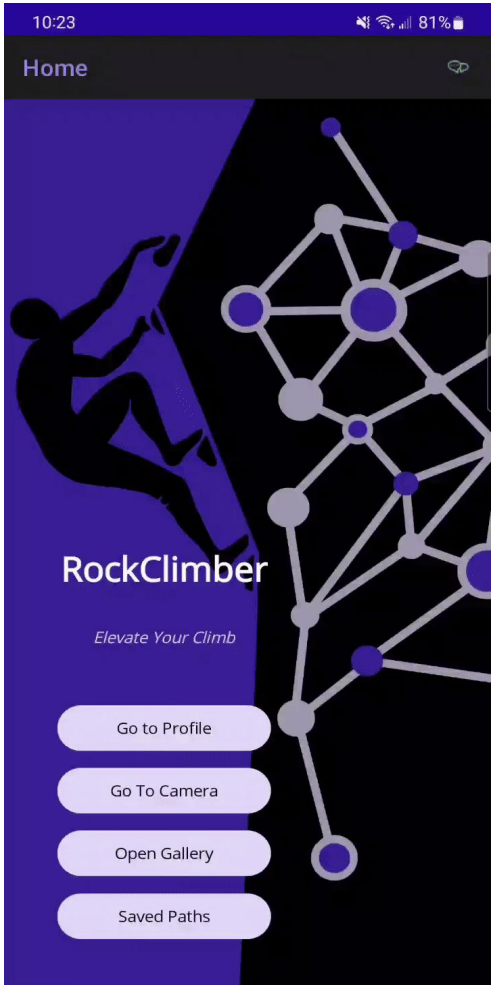
Simple and easy to use profile

- Enter your Name, Height, and Wingspan
- The name is used for reference in case multiple people use the app
- Height and Wingspan are critical for generating a optimal route for you



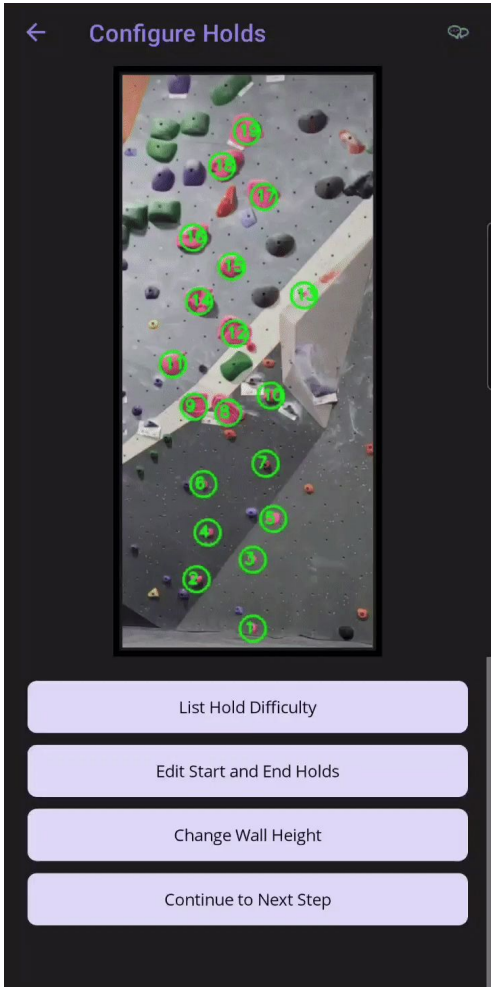
Selecting the route

- Using either your camera or a pre saved image from your gallery you can upload a picture of a route.
- Then you are able to select a wide range of colors that matches your desired route the closest
- Once you select the color all the identified holds will appear with numbers



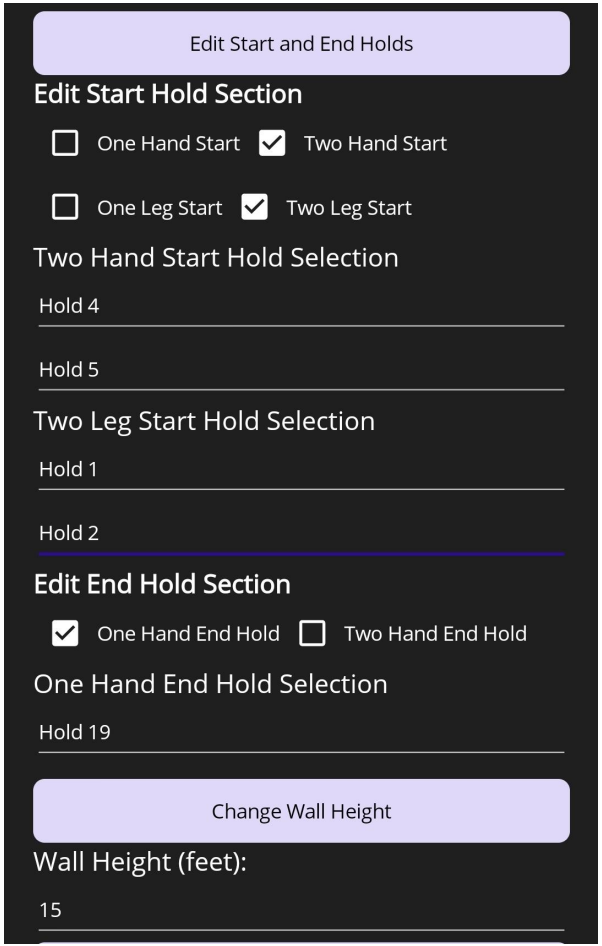
Customizing the route: Adjusting difficulty

- An optional feature allows you to modify holds that may look difficult.
- 4 options available Easy, Medium, Hard, Extreme
  - The harder the hold the less likely you are to have to interact with it
- All you have to do is select the desired hold in the side bar and it will automatically be updated on the layout.
- This feature is optional to make the app as beginner friendly as possible.



Customizing the route: Start, Finish, Wall height

- You are required to enter a starting point and end point.
- You can choose from 1 or 2 limb starts for hands and feet.
- You can choose 1 or 2 hand end as well
- Wall height is needed for reference
- Choosing the right starting and end point based on the layout of the wall can help accurately optimize the path

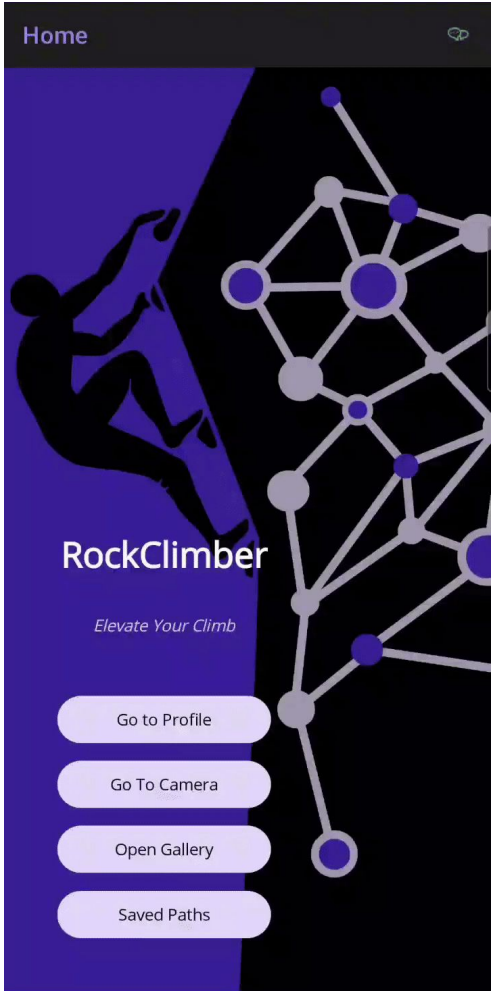


Final Path

- The final step is viewing the path which shows each step for all 4 limbs
- You can view them 1 step at a time or select view final path to see the entire path
- You can also save the route for future use

Saved paths

- You can view saved paths from the home page.
- Simply select the desired path to load it allowing you to view all the steps
- You can also delete the path once you no longer need it



Climbing Path

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.

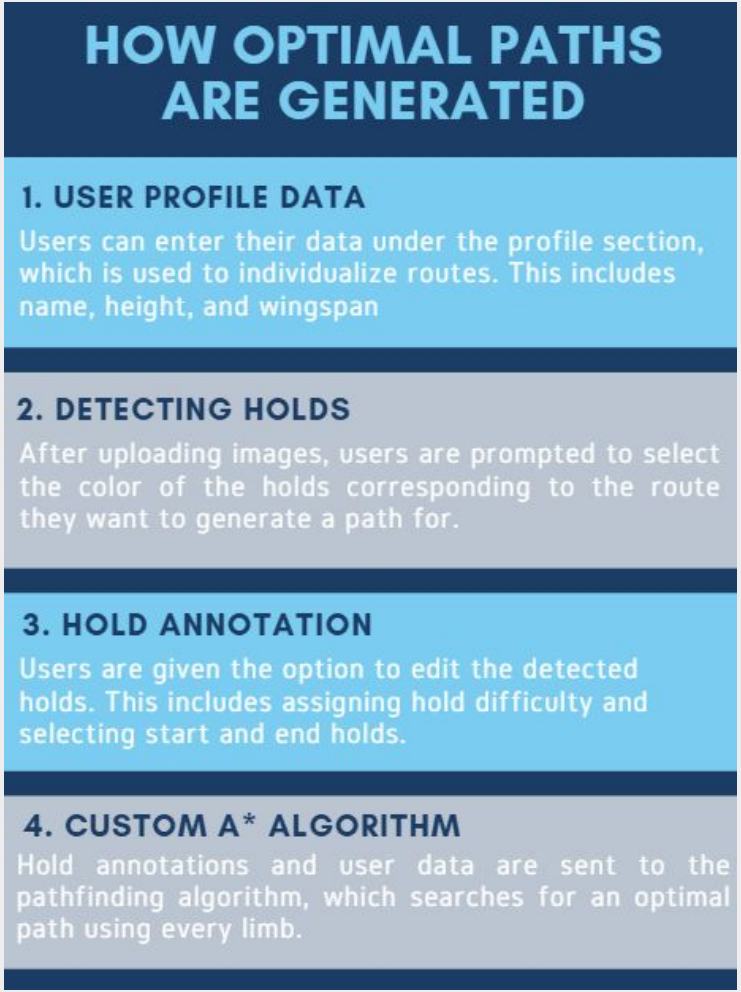
Technologies

- **Pathfinding AI:** A*
  - Simple and lightweight for this application
- **Blob Detection:** EMGU CV: OpenCV for blob detection
  - Used to identify holds by their color
- **Framework:** .NET MAUI with C# for app development
  - Runs and works well for android apps and possibility of expanding in the future
- **Database:** SQLite
  - to save and manage user data

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.

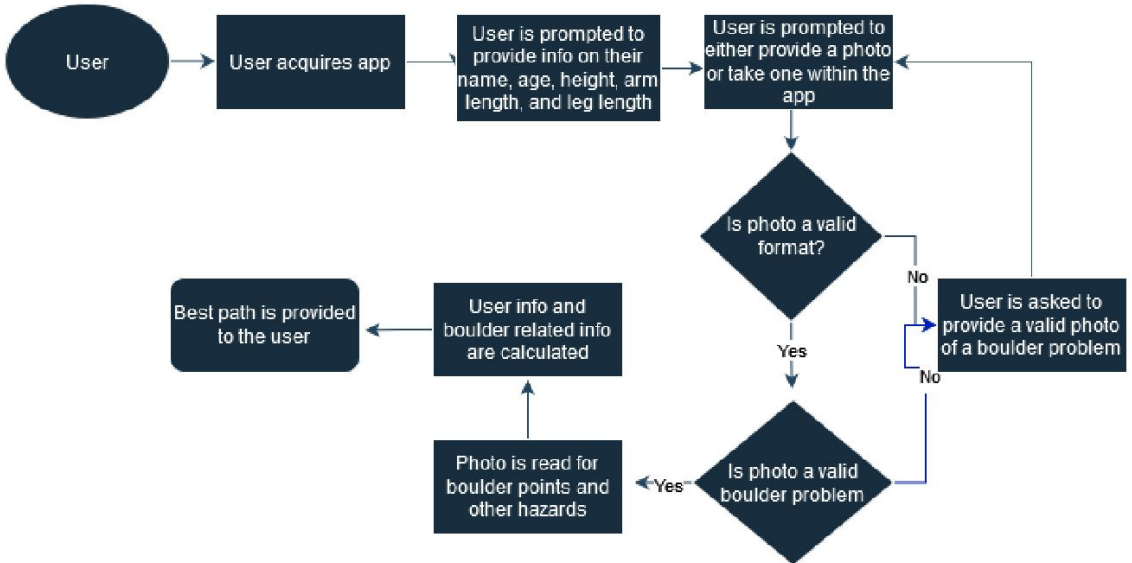


Challenges

- 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.

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.



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

February 2025:

- 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
- Created a path using the above information and displayed it to the user
- Optimized user annotation page with a simplified layout and a more streamlined layout
- Allowed user to save paths

March 2025

- Created a path for all 4 limbs using the above information
- Updated the UI to be more user friendly and readable
- Optimizing path generation to create better paths
- Testing
- Bug fixes

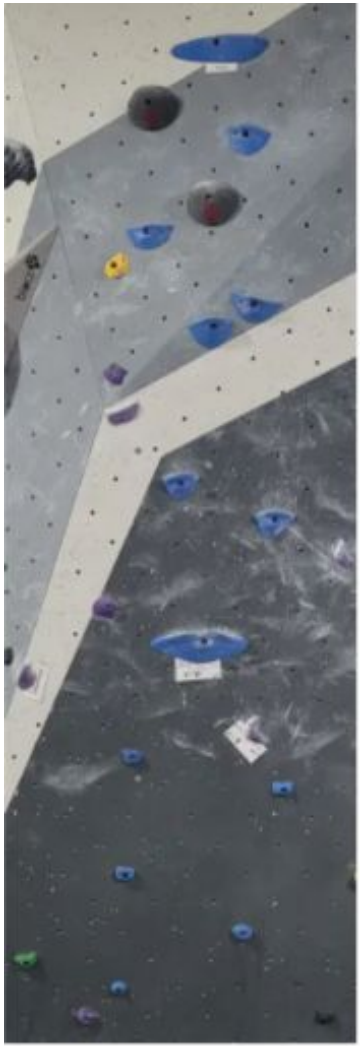
Results

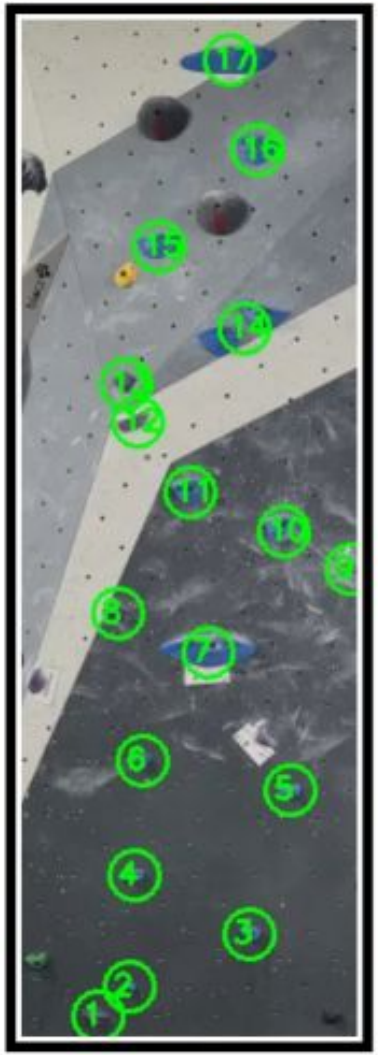
- User Profile where they can save their height and wingspan
- App loads a picture form the gallery or camera
- Blob Detection can recognize desired objects in the photo by color
- User can modify holds by difficulty, set a starting and end point for multiple scenarios (1-2 hand start, 1-2 foot start, 1-2 hand end)
- A easy to understand path is generated based on the users information showing both a step by step solution and the final all in one
- These results can be saved and viewed at any time in saved paths
- Made the UI more user friendly

Future Plans

- **Improve Pathfinding**
  - Current approach relies too heavily on sets of static rules within the heuristic, missing edge cases and limiting usefulness at harder difficulties.
  - We would improve this going forward by modeling biomechanics. With a better understanding of how the human body can move on the wall, we can ensure generated paths are feasible.
  - We would modify our search to grade potential moves based on the overall body position of the climber instead of just what is the “easiest” move at a given point in time.

- **Enhanced Blob Detection**
  - Instead of a static dropdown of colors for the climber to choose from, make the blob detection find the colors within the provided image and allow the user to select from those colors.
  - Investigate more into contour detection to try and determine the directions in which holds must be grabbed (i.e. hold must be grabbed on the left side, or on the top). This will aid in tracking the forces acting on the climber and result in more feasible paths.

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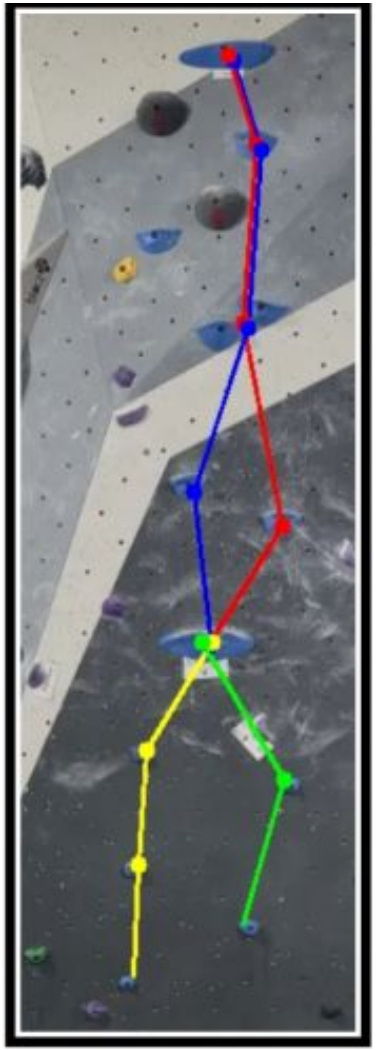

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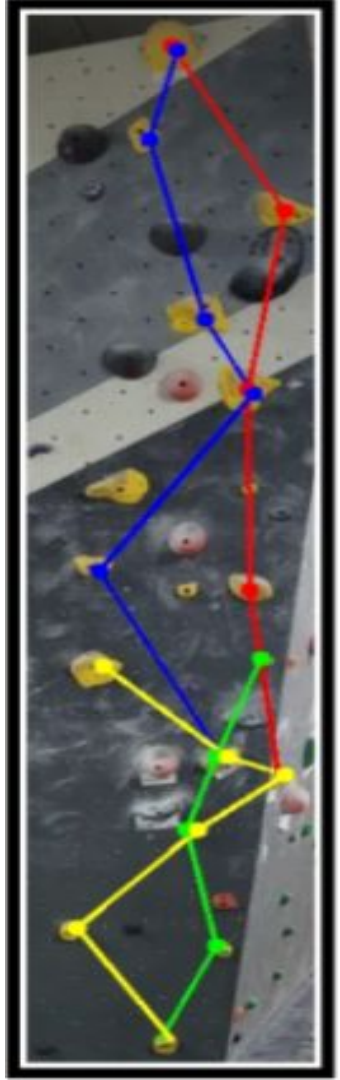

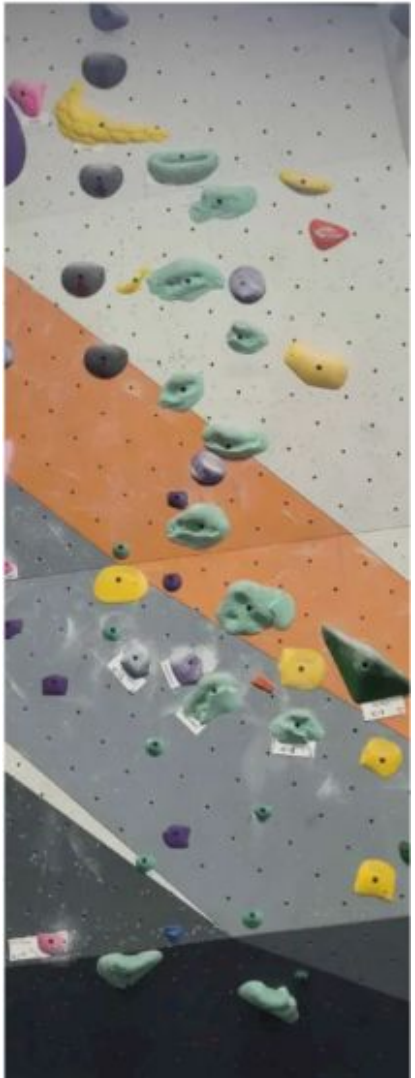

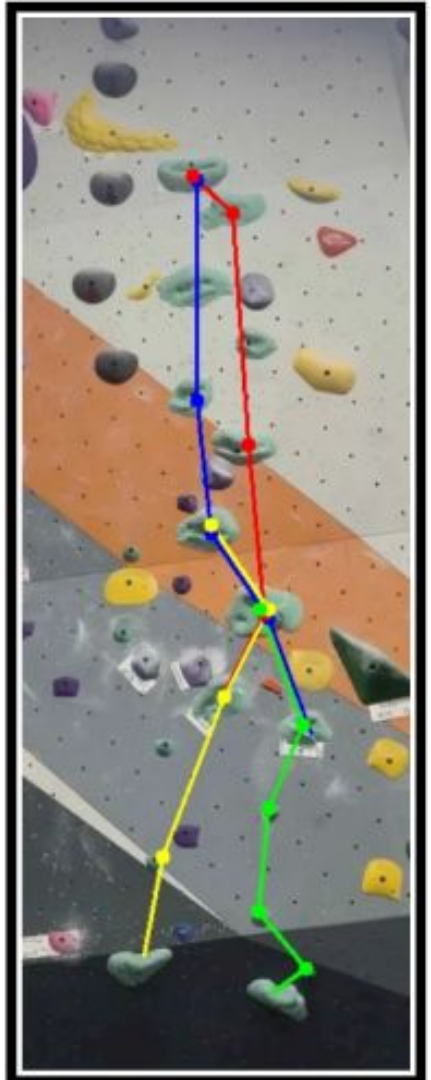

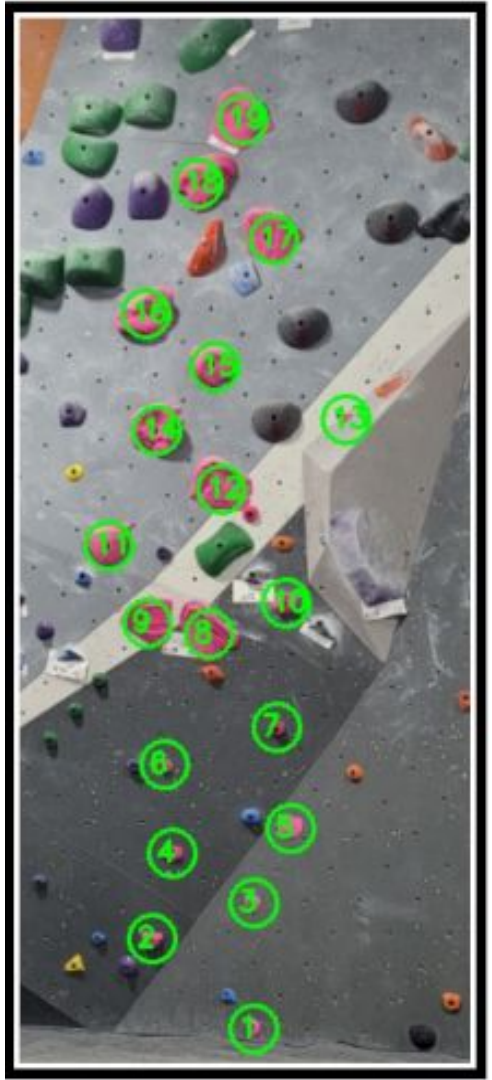
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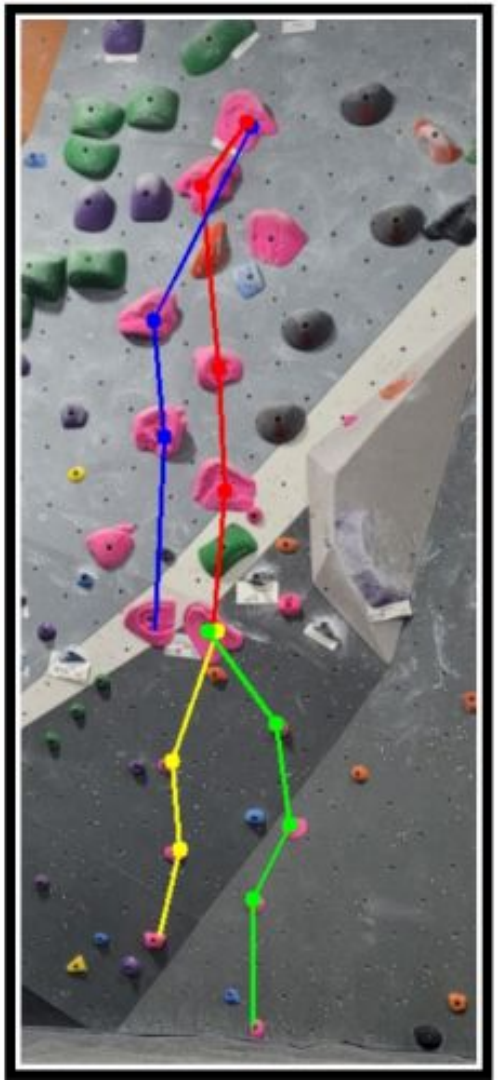

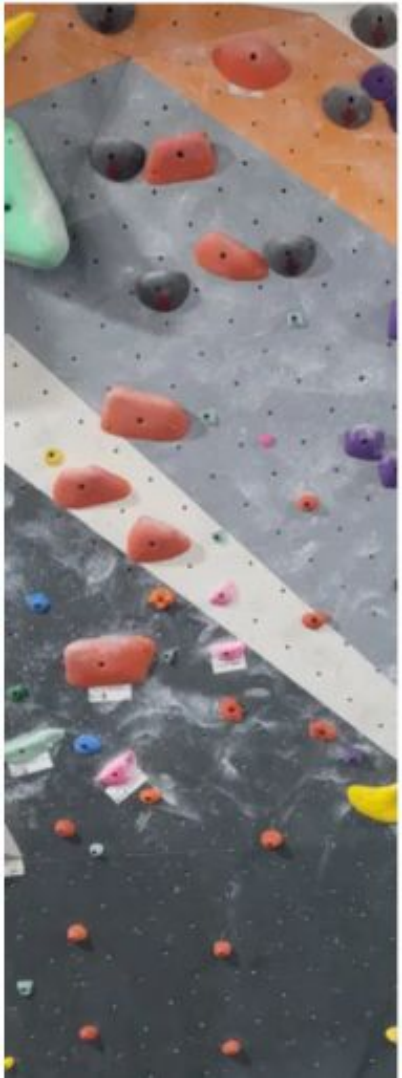

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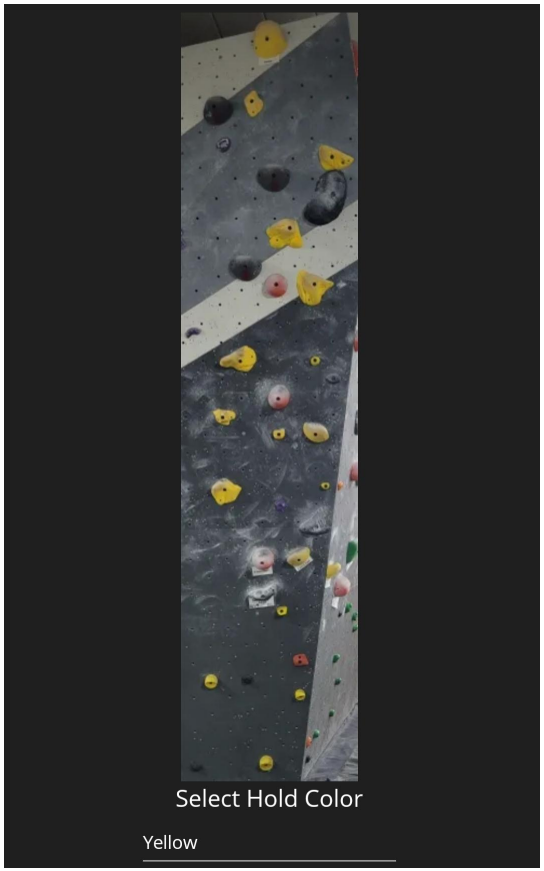
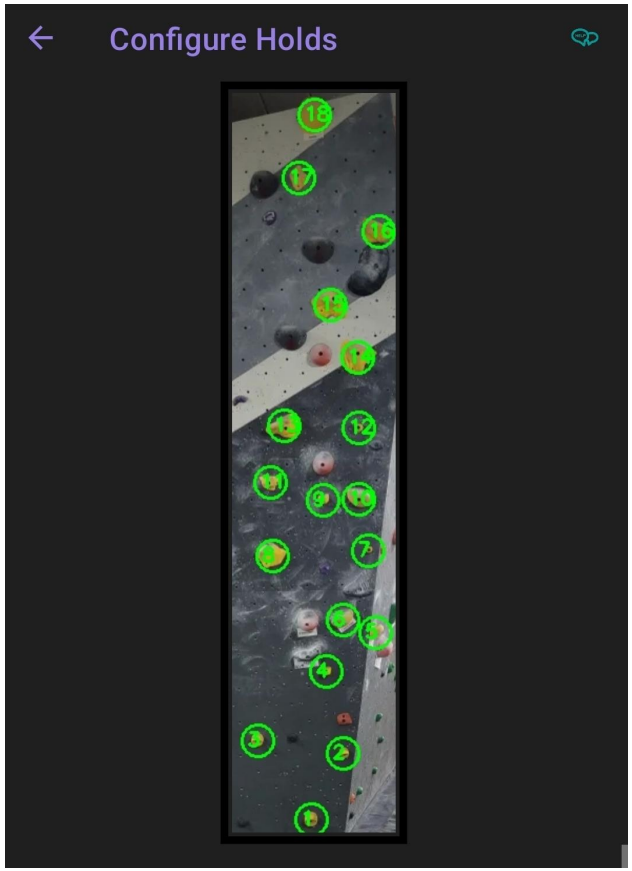
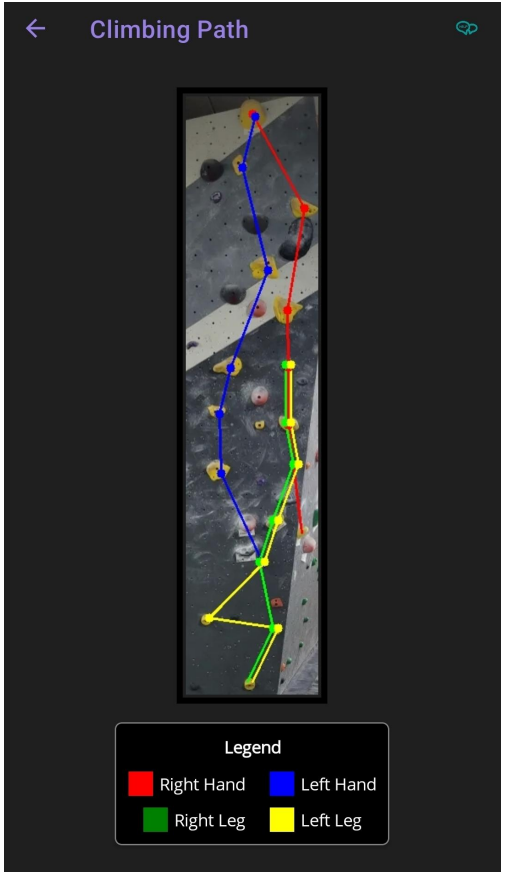
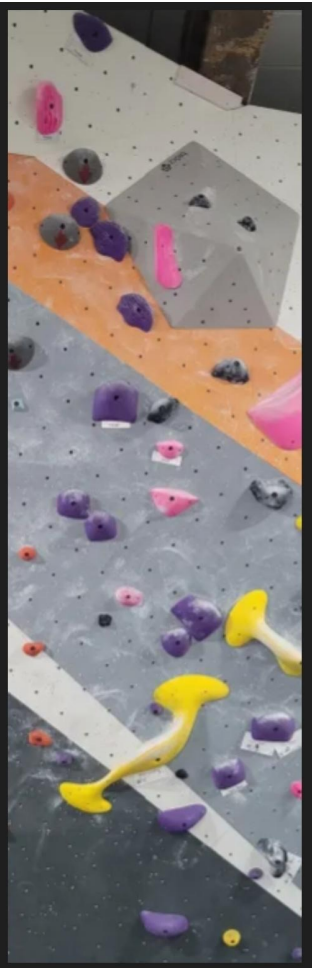
Additional Examples of paths









Select Hold Color

Purple

Configure Holds

Climbing Path

Legend

Right Hand

Left Hand

Right Leg

Left Leg

Select Hold Color

Pink

Confirm

Configure Holds

Climbing Path

Legend

Right Hand | Left Hand

Right Leg | Left Leg