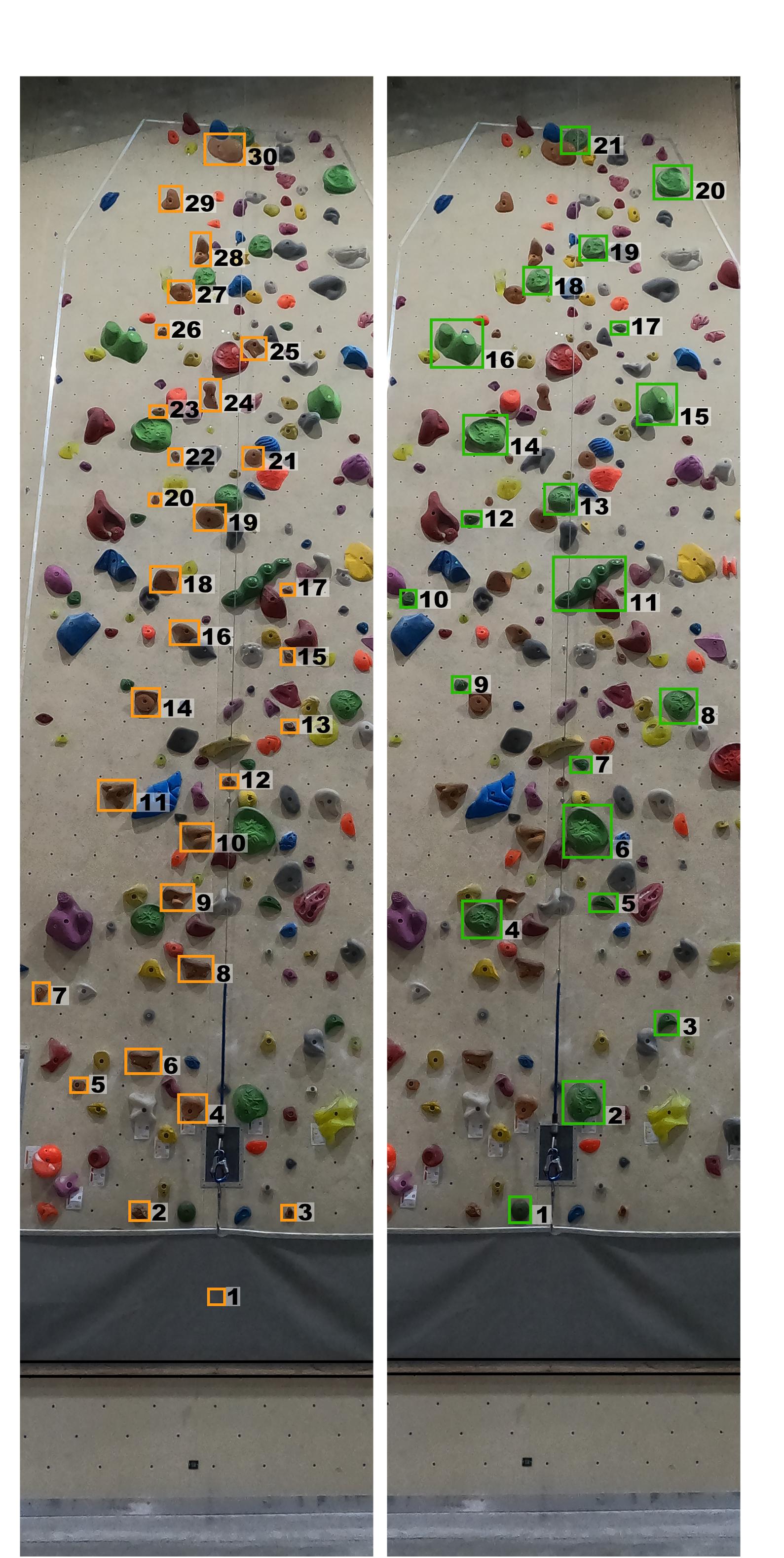


The Way Up: A Dataset for Hold Usage Detection in Sport Climbing



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Motivation

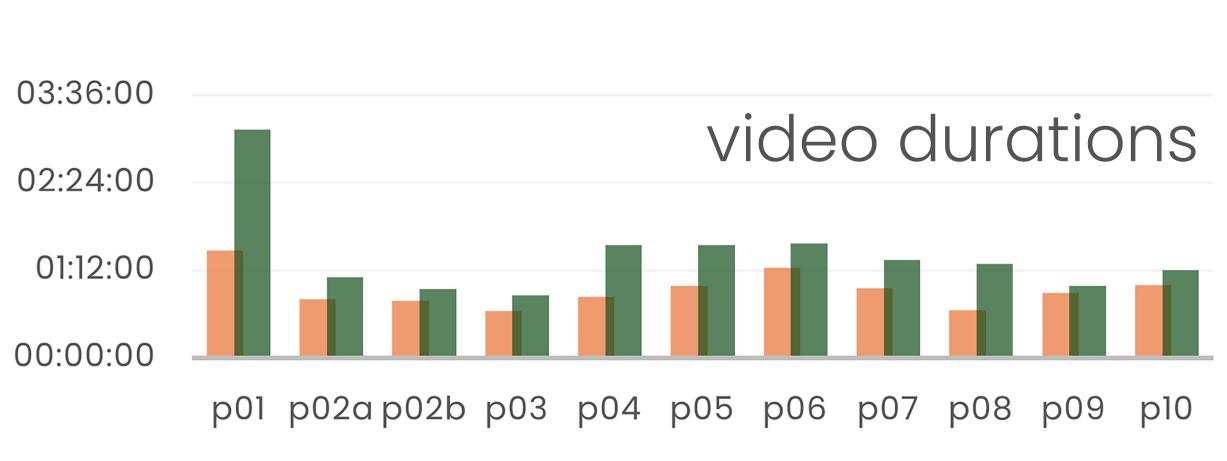
Sport climbing is growing in popularity, including as an Olympic discipline

- We propose a dataset to support automated hold usage detection.
- Long-term goal: accessible climbing assistance for the visually impaired.



Dataset

22 videos of 10 different climbers* in 2 different routes



940 hold usages

| 481 by hand | 459 by foot |
|------------------|-----------------|
| 444 orange route | 496 green route |

5.27s avg. hold usage duration

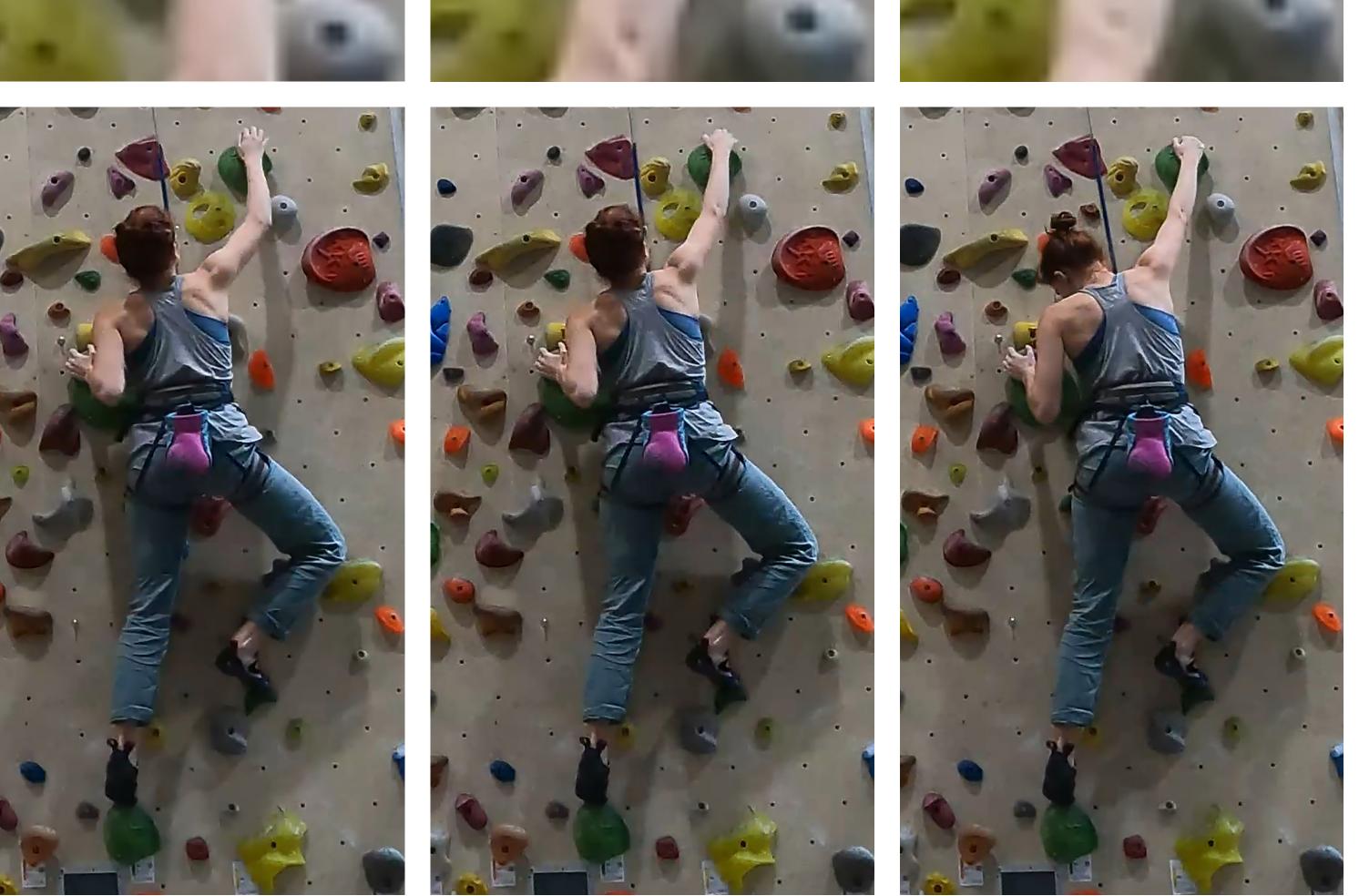
| 5.55s avg. for hands | 4.97s avg. for feet |
|-------------------------|------------------------|
| 6.16s avg. orange route | 4.28s avg. green route |

26.98% avg. hold occlusion

| 50.5% avg. for hands | 2.2% avg. for feet |
|-------------------------|------------------------|
| 27.8% avg. orange route | 26.2% avg. green route |

*one participant climbed both routes twice

not touched touched used



Annotation Format

| extr. | hold | start | end | occluded |
|-------|------|-------|-----|----------|
| lh | 4 | 260 | 358 | 260-284 |
| rh | 4 | 260 | 382 | 260-332 |
| lf | 0 | 292 | 465 | none |
| ••• | ••• | ••• | ••• | ••• |



Experiments

Evaluate different pose estimation models for automatically detecting hold usage, by detecting overlap of the hold bounding box and an area of interest around hand/foot keypoints.

Results:

Accuracies for detecting hold usage with tloU>0

| | orange | | green | | | both | | | |
|---------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|
| model | hands | feet | comb. | hands | feet | comb. | hands | feet | comb. |
| ViTPose L | 74.5% | 94.3% | 83.6% | 86.0% | 94.7% | 89.9% | 80.1% | 94.5% | 86.6% |
| YOLOv8 pose X | 67.5% | 74.3% | 70.9% | 80.7% | 79.7% | 80.2% | 73.9% | 76.8% | 73.9% |
| MediaPipe H | 71.1% | 90.9% | 80.3% | 82.3% | 92.9% | 87.0% | 76.6% | 91.9% | 76.6% |



| model | orange | green | both |
|---------------|--------|-------|-------|
| ViTPose L | 68.0% | 70.6% | 69.3% |
| YOLOv8 pose X | 59.4% | 66.3% | 62.8% |
| MediaPipe H | 64.6% | 71.8% | 68.2% |

Processing times

| model | avg. sec. / frame | avg. FPS |
|---------------|-------------------|----------|
| ViTPose L | 0.25 s | 4.11 FPS |
| YOLOv8 pose X | 0.15 s | 7.06 FPS |
| MediaPipe H | 0.12 s | 8.19 FPS |

Key challenges:

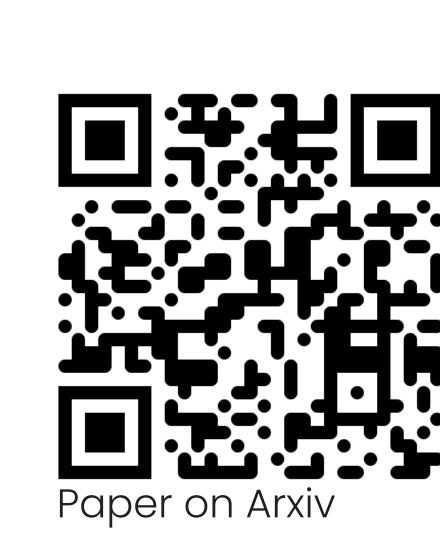
- Footholds are mainly used with the toes, while hand holds are mostly used with the entire hand.
- Climbers frequently self-occlude bodyparts, including their heads.
- Unconventional poses while climbing.



toe keypoints ankle keypoints

Future Work

- Extend the dataset with different wall angles and heights.
- Evaluate other approaches for hold usage detection.
- Fine-tune a pose estimation model on climbing data.
- Predict the next hold to be used by the climber.



orange route

green route