Computer Vision A.Y. 23-24

Real-Time Posture Correction with MediaPipe and OpenCV

BY LUCIA FORES 1836451

Project Introduction

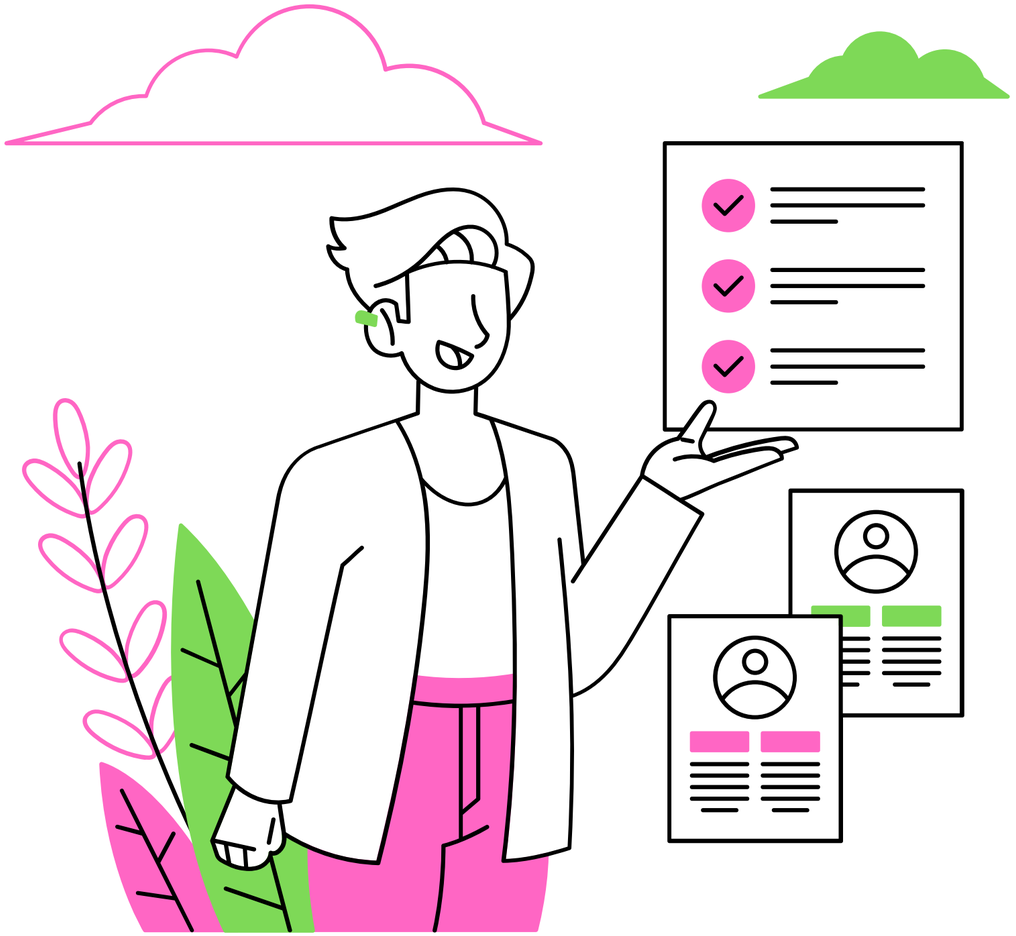
Country Income (World Bank Classification[a])	Countries (n)	Median of mean sitting times median hours (IQR)
Low-income	6	2.7 (2.6–3.3)
Lower-middle income	6	3.1 (2.6–3.6)
Upper-middle income	12	3.9 (3.2–5.1)
High-income[b]	38	4.9 (4.7–5.3)
Total	62	4.7 (3.5–5.1)

Median of mean sitting times by country income classification [1]

Rank	Trend
1	Wearable technology
2	Strength training with free weights
3	Body weight training
4	Fitness programs for older adults
5	Functional fitness training
6	Outdoor activities
7	High-intensity interval training (HIIT)
8	Exercise for weight loss
9	Employing certified fitness professionals
10	Personal training
11	Core training
12	Circuit training
13	Home exercise gyms
14	Group exercise training
15	Exercise is Medicine
16	Lifestyle medicine
17	Yoga
18	Licensure for fitness professionals
19	Health/well-being coaching
20	Mobile exercise apps

Top 20 Worldwide Fitness Trends for 2023 [3]

During COVID-19 restrictions home exercise became widely spread among people [2]



Problem Statement

- Home workout can easily bring to **injuries** [4]
- Having a bad posture for a long time can affect the **musculo-skeleteal** system and the **lungs** [5]

Proposed Solution

- Implementation of the algorithm proposed by Yejin Kwon and Dongho Kim in [6] to **correct the user posture** while executing the **squat** and **push-up** exercises
- Expansion of the algorithm to the **sitting** posture
- Integration of the correction system for the sitting posture with an **handed Arduino system**

Main Technologies

The project was made thanks to the use of MediaPipe Pose and OpenCV

MediaPipe Pose

MediaPipe Pose is a ML solution developed by Google.
The pose landmarker enabled the detection of **points of interest** on the user's body for posture calculation

OpenCV

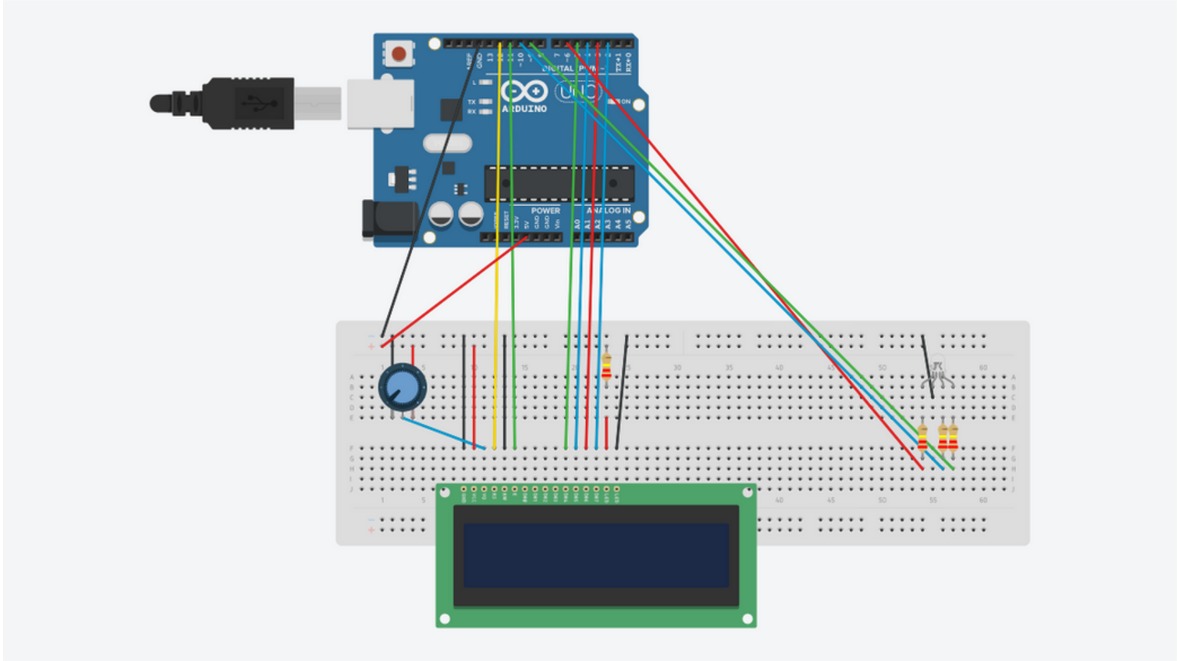
OpenCV is the biggest open-source library for computer vision.
Thanks to its usage, a **real time video capture** of the user and a consequent **feedback** has been made

Handed Arduino System

The alarm system device for the sit posture correction has been made thanks to Arduino

Arduino

Arduino is an open-source electronic prototyping platform.
The electronic prototype system created is an **alarm system** that reacts to the posture correction algorithm

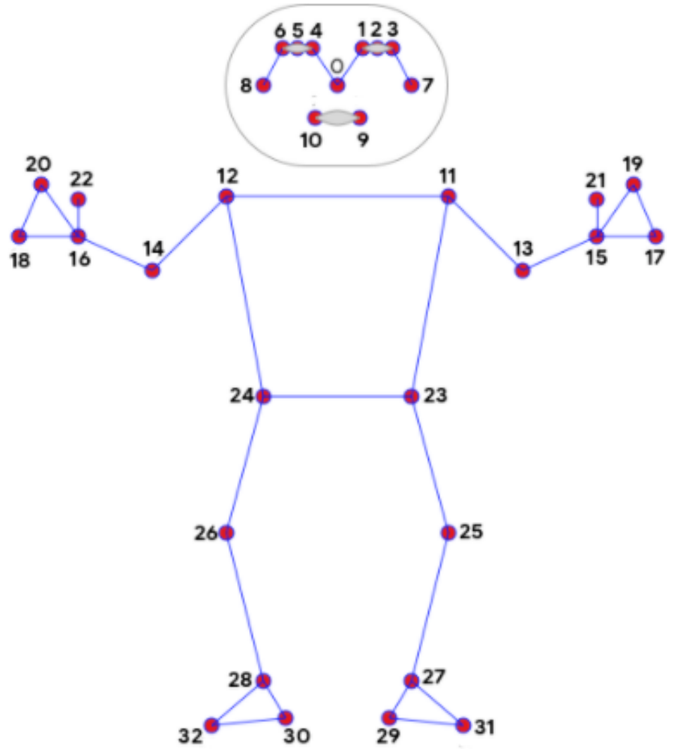


Circuit scheme of the realized handed system

Landmarks

The landmarks needed for the project are specific for each one of the postures detected.

- **sitting (x, y):**
  - Ears (7/8)
  - Shoulders (11/12)
  - Hips (23/24)
- **squat (x, y, z):**
  - Knees (25/26)
  - Hips (23/24)
  - Shoulders (11/12)
  - Foot (31/32)
- **pushup (x, y, z):**
  - Wrists (15/16)
  - Elbows (13/14)
  - Shoulders (11/12)
  - Ankles (27/28)
  - Hips (23/24)



0. nose
1. left_eye_inner
2. left_eye
3. left_eye_outer
4. right_eye_inner
5. right_eye
6. right_eye_outer
7. left_ear
8. right_ear
9. mouth_left
10. mouth_right
11. left_shoulder
12. right_shoulder
13. left_elbow
14. right_elbow
15. left_wrist
16. right_wrist
17. left_pinky
18. right_pinky
19. left_index
20. right_index
21. left_thumb
22. right_thumb
23. left_hip
24. right_hip
25. left_knee
26. right_knee
27. left_ankle
28. right_ankle
29. left_heel
30. right_heel
31. left_foot_index
32. right_foot_index

Google's MediaPipe Pose Landmark map

Proposed Algorithm

The proposed algorithms rely on **angles and distances computations**.
Notice that the loop for the posture correction is entirely executed **for each frame** of the video capture and for this reason it is executed while the **webcam is open**

1. Given the selected posture the corresponding landmarks are saved
2. Thanks to the saved landmarks the needed angles and distances are computed
3. The angles and distances are compared with the ones indicated by the heuristics
4. Given the result of the compare a feedback to the user is created
5. The feedback and the angles are presented in real-time to the user

Formulas and Heuristics – 1 –

Sitting Posture

$$\text{dist} = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

$$\theta = \arccos\left(\frac{(y2 - y1) \cdot (-y1)}{\sqrt{(x2 - y2)^2 + (y2 - y1)^2} \cdot y1}\right)$$

$$\text{degree} = \left\lfloor \frac{180}{\pi} \right\rfloor \cdot \theta$$

- shoulders distance < 100
- neck angle < 70 (shoulder - ear angle)
- torso angle < 70 (hip - shoulder angle)

Formulas and Heuristics - 2 -

Exercises Postures

$$\overrightarrow{CA} = (x1 - x3,\ y1 - y3,\ z1 - z3)$$

$$\overrightarrow{CB} = (x2 - x3,\ y2 - y3,\ z2 - z3)$$

$$\overrightarrow{CA} \cdot \overrightarrow{CB} = |\overrightarrow{CA}||\overrightarrow{CB}|\cos(\theta)$$

$$\theta = \cos^{-1}\frac{\overrightarrow{CA} \cdot \overrightarrow{CB}}{|\overrightarrow{CA}||\overrightarrow{CB}|}$$

$$height = \text{round}\left(|y_1 - y_2|, 3\right)$$

$$\text{width} = \text{round}\left(|x_1 - x_2|, 3\right)$$

Squat

- 60 <= hip angle <= 120

(knee - hip - shoulder angle)

- knee - hip height <= 0.2
- foot - knee width <= 0.1

Push-Up

- 70 <= elbow angle <= 100

(wrist - elbow - shoulder angle)

- 160 <= body angle <= 200

(ankle - hip - shoulder angle)

Discussion and Analysis

01. The **sitting posture** correction algorithm works only with the user **placed in profile**. The right side has been chosen in the project

02. Right and left body angles can be **different** so an average of the two is used as the reference angle

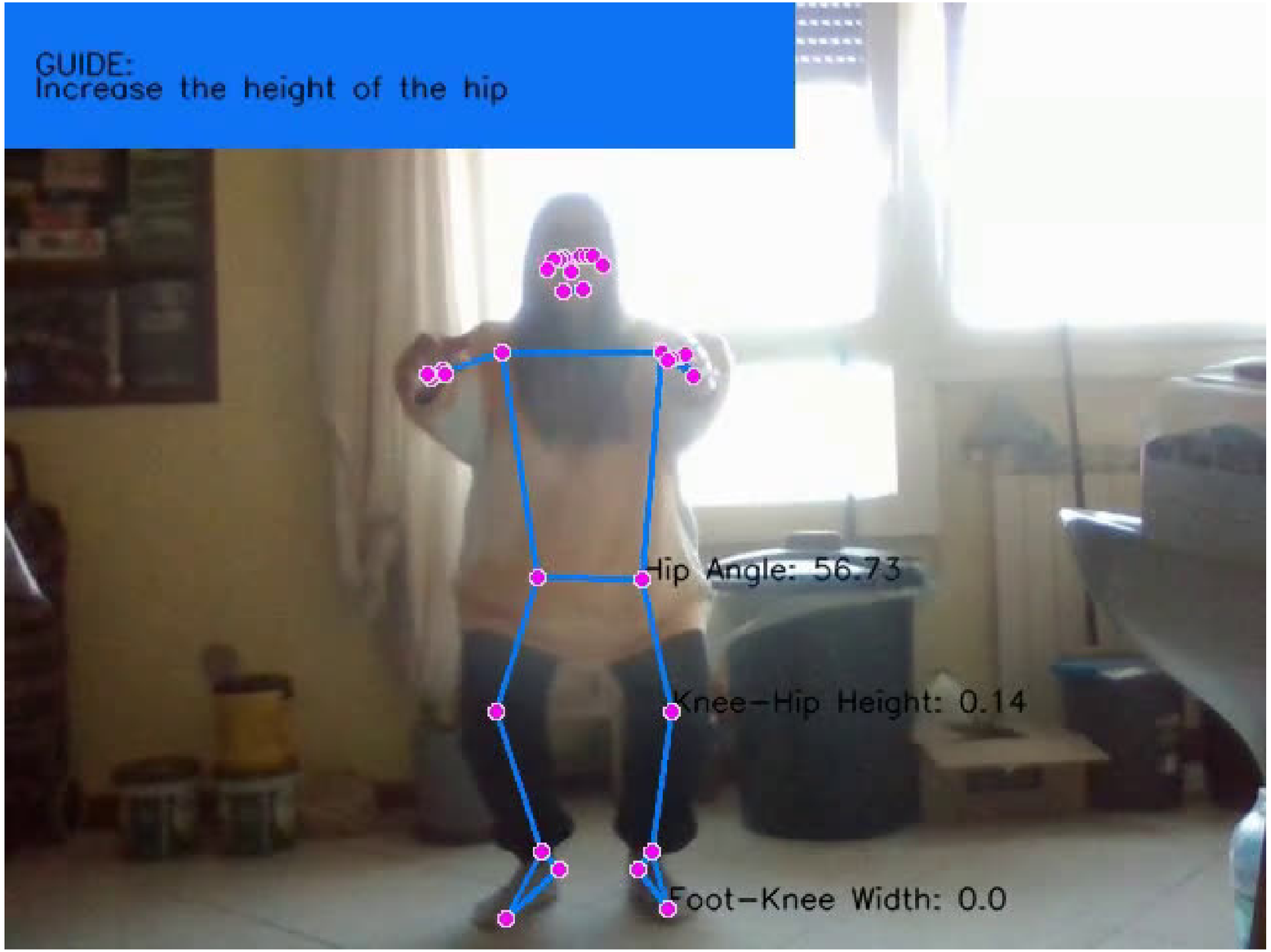
03. The video capture of the user is saved so that it can be later viewed to **check one's errors**

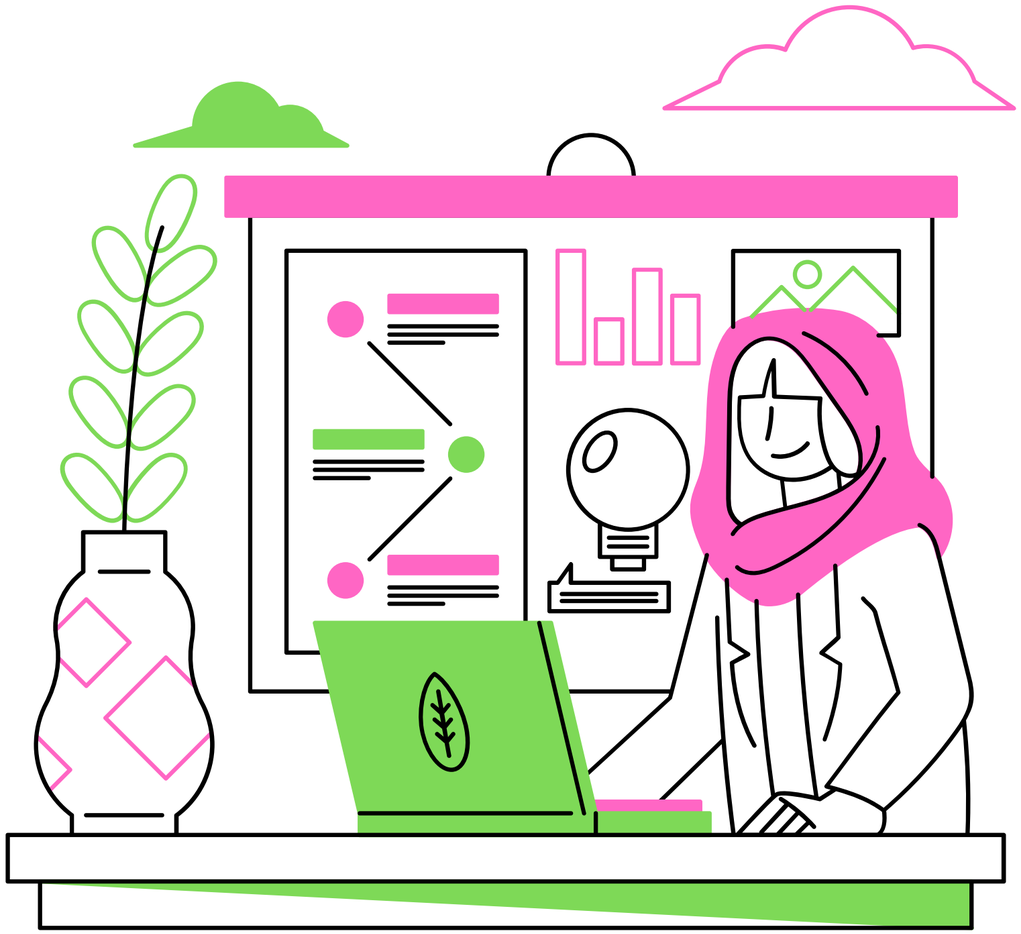
04. The handed Arduino system has been thought to be used as a system alert when the **user cannot focus on the video capture**

Future Work and Recommendations

- Integration of exercises repetition counter
- Expansion of the Arduino integration to all exercises
- Voice feedback
- Implementation of several difficulties for each exercise
- Implementation of other exercises

Preview


GUIDE:
Increase the height of the hip
Hip Angle: 56.73
Knee-Hip Height: 0.14
Foot-Knee Width: 0.0



Let’s see it in action!

References

[1] Mclaughlin, M., Atkin, A.J., Starr, L. et al. Worldwide surveillance of self-reported sitting time: a scoping review. Int J Behav Nutr Phys Act 17, 111 (2020). https://doi.org/10.1186/s12966-020-01008-4
[2] J. Wilke et al., "Restrictercise! Preferences Regarding Digital Home Training Programs during Confinements Associated with the COVID-19 Pandemic",
International Journal of Environmental Research and Public Health, Vol. 17, No. 18, Sep. 2020.
https://dx.doi.org/10.3390%2Fijerph17186515
[3] Thompson, Walter R. Ph.D., FACSM. Worldwide Survey of Fitness Trends for 2023. ACSM's Health & Fitness Journal 27(1):p 9-18, 1/2 2023. | DOI: 10.1249/FIT.0000000000000834
[4] Hertel G, Hochrein A, Suren C, Minzlaff P, Banke IJ, Willers J, von Eisenhart-Rothe R, Prodinger PM. Injury incidence and specific injury patterns in app-based bodyweight training (Freeletics): results of an international survey with 3668 participants. BMC Sports Sci Med Rehabil. 2022 Jul 26;14(1):145.
doi: 10.1186/s13102-022-00525-y. PMID: 35883184; PMCID: PMC9321304.
[5] Szczygieł E, Zielonka K, Mętel S, Golec J. Musculo-skeletal and pulmonary effects of sitting position – a systematic review. Ann Agric Environ Med. 2017;24(1):8-12. doi:10.5604/12321966.1227647.
[6] Kwon, Yejin & Kim, Dongho. (2022). Real-Time Workout Posture Correction using OpenCV and MediaPipe. The Journal of Korean Institute of Information Technology. 20. 199-208.
https://dx.doi.org/10.14801/jkiit.2022.20.1.199.

Thank you!

Questions?

BY LUCIA FORES 1836451