

Instant posture adjustment in Real-time with MediaPipe and OpenCV



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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]

Project Introduction

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



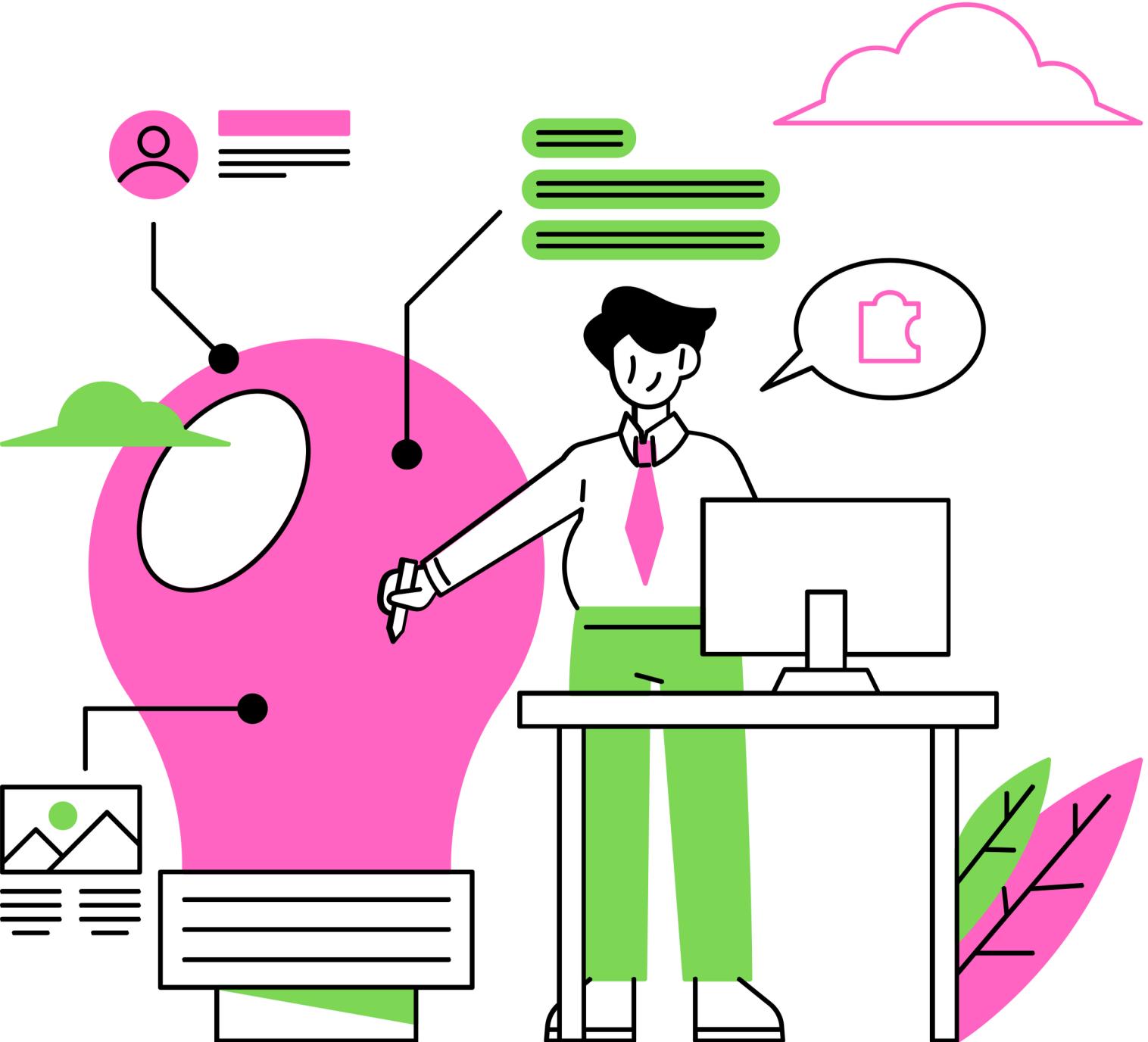


Problem Statement

Home workout can easily bring to **injuries** [4]
Having a bad posture for a long time can affect the **musculo-skeletal** 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.
-



Technologies Used

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

Landmarks

The landmarks needed for the project are specific for each posture detected.

- **sitting (x, y):**

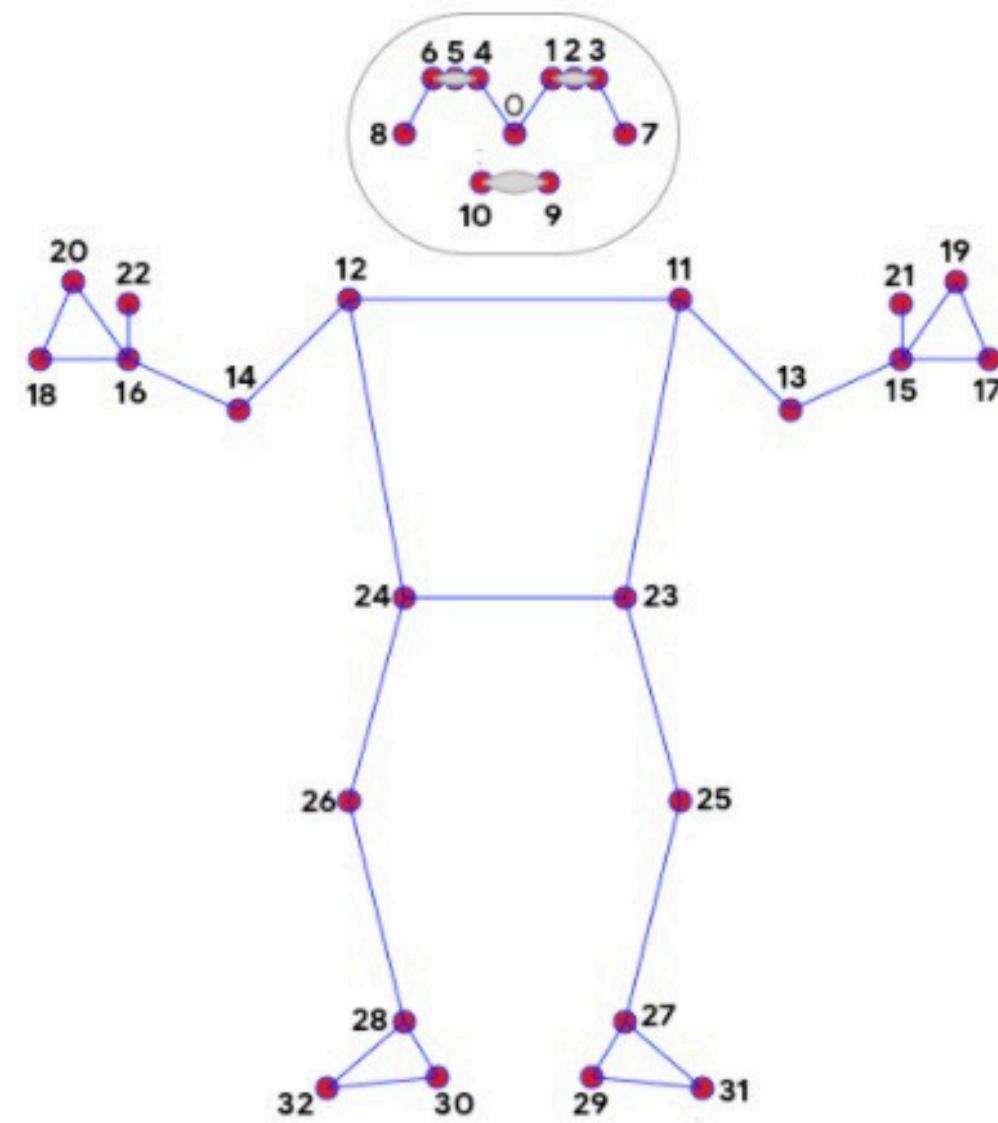
- Ears (7/8)
- Shoulders (11/12)
- Hips (23/24)

- **pushup (x, y, z):**

- Wrists (15/16)
- Elbows (13/14)
- Shoulders (11/12)
- Ankles (27/28)
- Hips (23/24)

- **squat (x, y, z):**

- Knees (25/26)
- Hips (23/24)
- Shoulders (11/12)
- Foot (31/32)



Google's MediaPipe Pose Landmark map

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

Proposed Algorithm

The proposed algorithms rely on **angles and distance 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 comparison, 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

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

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

$$\text{degree} = \left[\frac{180}{\pi} \right] \cdot \theta$$

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

Formulas and Heuristics - 2 -

Exercises Postures

$$\vec{CA} = (x_1 - x_3, y_1 - y_3, z_1 - z_3)$$

$$\vec{CB} = (x_2 - x_3, y_2 - y_3, z_2 - z_3)$$

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

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

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

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

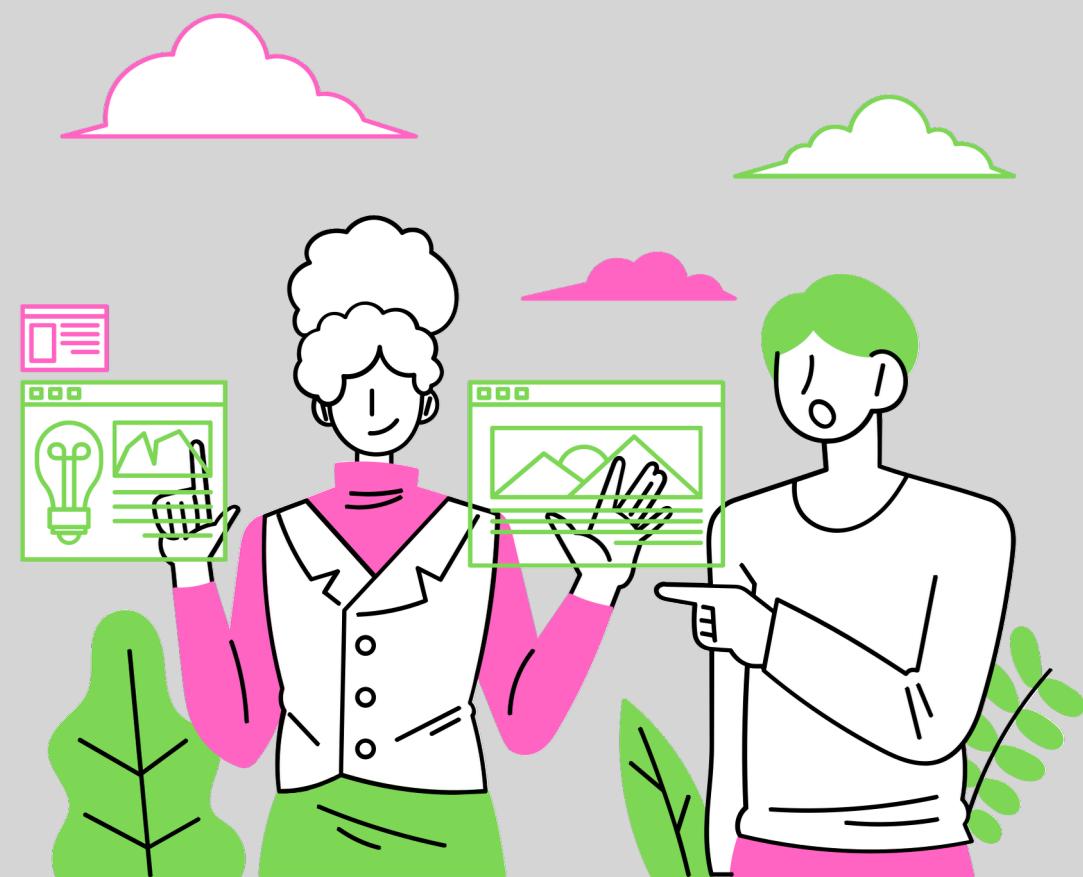
Squat

- $60 \leq \text{hip angle} \leq 120$
(knee - hip - shoulder angle)
- knee - hip height ≤ 0.2
- foot - knee width ≤ 0.1

Push-Up

- $70 \leq \text{elbow angle} \leq 100$
(wrist - elbow - shoulder angle)
- $160 \leq \text{body angle} \leq 200$
(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.

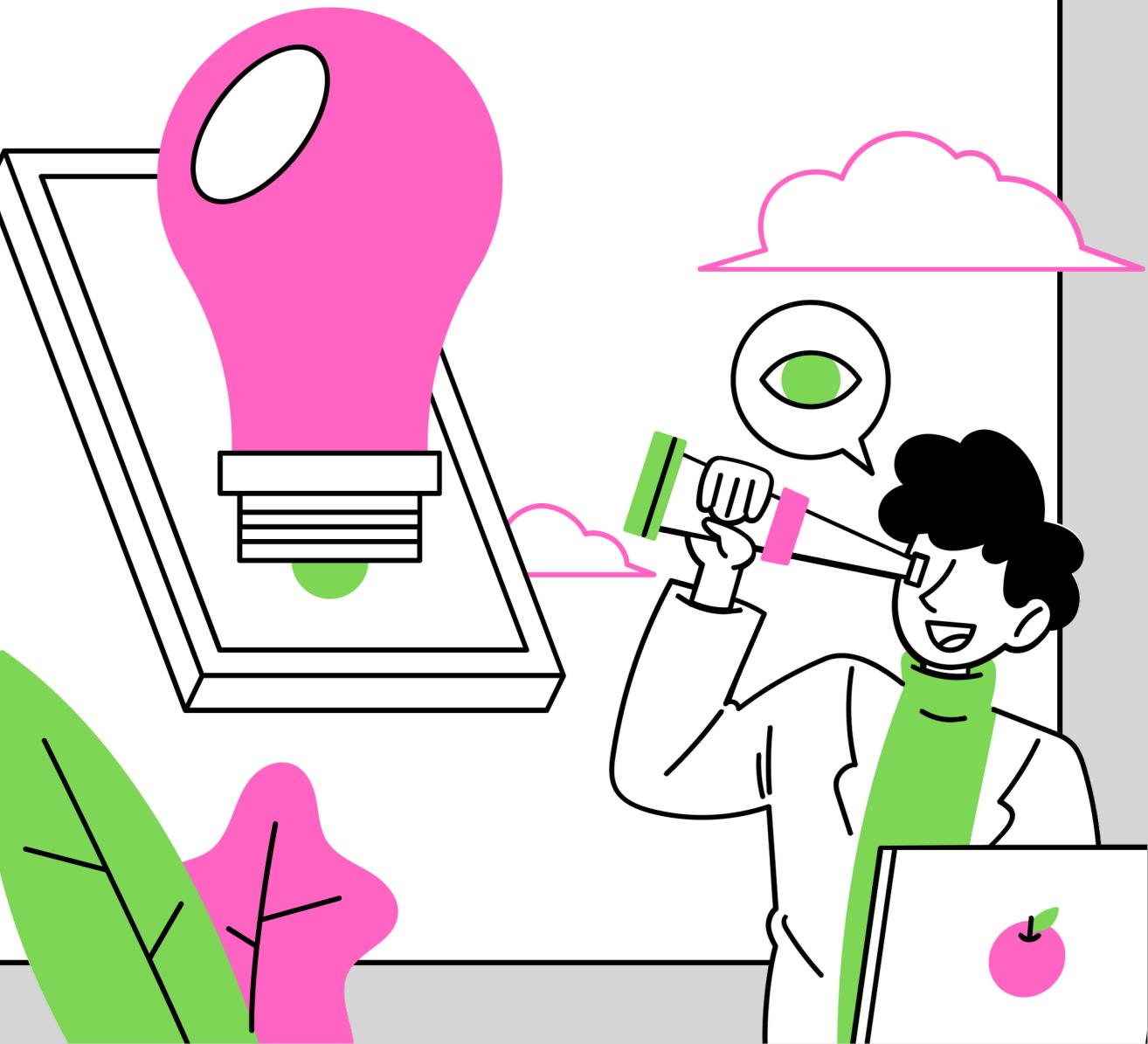
The video capture of the user is saved so that it can be later viewed to **check one's errors**

04.

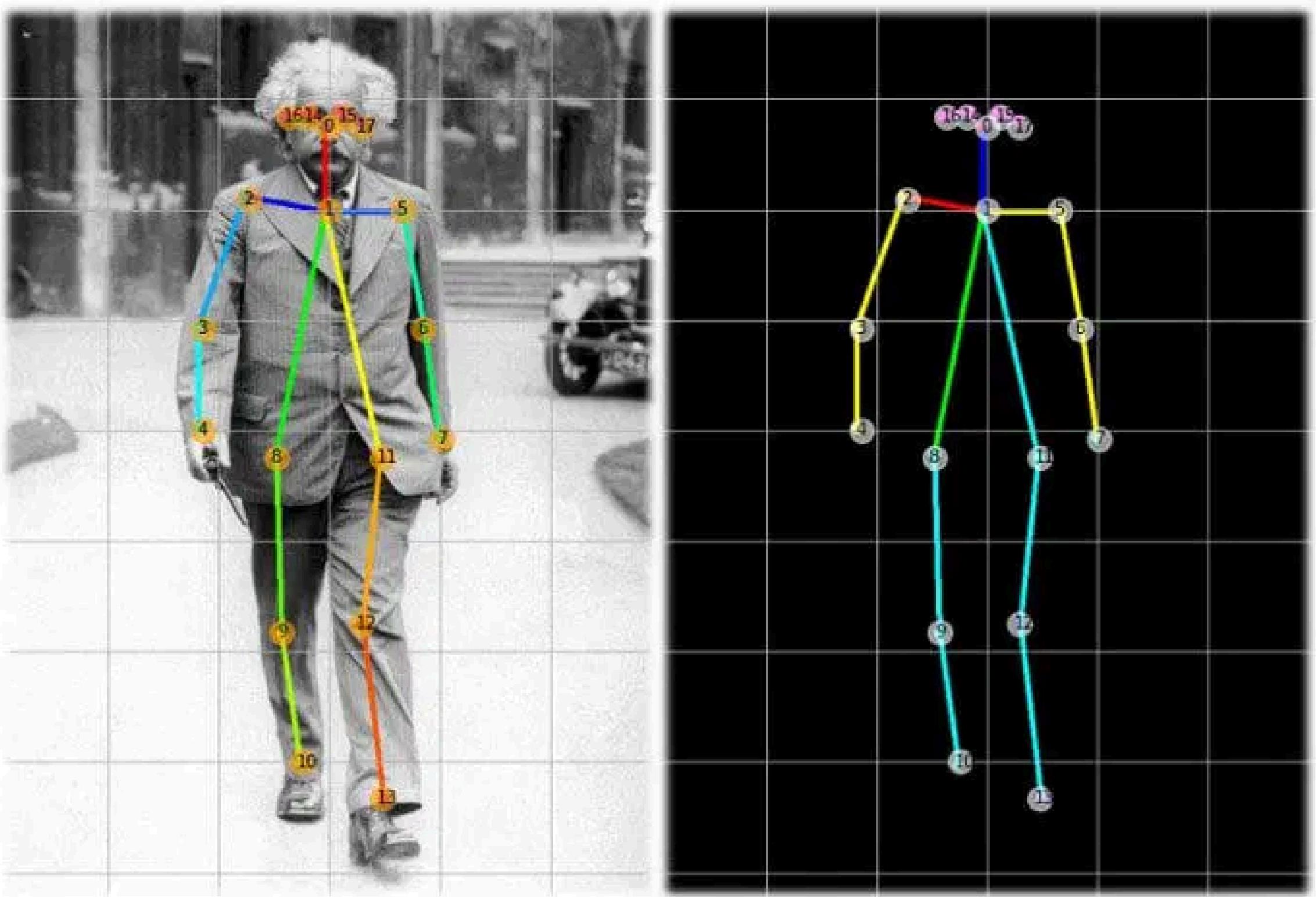
The handed Arduino system has been thought to be used as a system alert when the **user cannot focus on the video capture**

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



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>
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- [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
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- [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!