Gait Analysis

Mila Marinković

Faculty of Computer and Information Science
University of Ljubljana
Slovenia
mm9136@student.uni-lj.si

Abstract. The gait analysis is systematic study that aims to study the human motion. In this paper we aim to reconstruct the Coincidence platform from Matrix-Coincidence Laboratory, that aims to compare the gait of two people by performing human pose estimation using MediaPipe framework, after which we connected captured keypoints of two different person. In the end, we impemented ORB algorithm.

Keywords: Gait recognition · Pose estimation · MediaPipe · ORB detector.

1 Introduction

According to psychological studies, humans have a small but significant ability to recognize people they know by their gait. This ability has encouraged research on using gait as a biometric identification method. Through the technology of computer vision, a person's gait becomes a completely measurable record, which is included in the database of the behavior of the individual, in his portfolio, medical record, or any other archive of the organization of individuals in society. For that reason, the Matrix-Coincidence Laboratory consists of two platforms that serve to extract the "natural" human mark through walking. The first platform is the Matrix platform, and the other is the Coincidence platform, where the participant walks on the treadmill while the computer vision registers a moving three-dimensional "architecture" of moving selected points along his body, arms, and legs [1].

As a part of the course Interaction and Information Design, our task was to reconstruct the Coincidence platform. More precisely, the task was to capture and visualize gait, which covers gait detection, point capture, and the display of points on video. Once we have points on the participant walking on the treadmill, we should connect suitable points from that participant with the other person's points from the second video. In order to get more connections between those two participants, we also needed to implement image matching algorithm. In this way, we did gait comparison and analysis of two person.

2 Related Work

Since the time of Aristotle in the fourth century BC, people have been curious about the ways that animals and other people walk [?]aris). Borelli used staggered poles to analyze his own movement, but modern gait analysis tools now include three-dimensional motion capture, instrumented gait mats, and a range of wearable gadgets.

Recent advancements in video-based posture estimation have made it possible to automatically analyze both human [3–8] movements using only digital video inputs. Human posture estimation methods involve learning algorithms that rely on networks that are often trained on a large number of photographs of various people. This process created robust networks that are capable of spotting keypoints (such as body landmarks) in fresh images outside of the training dataset.

Markerless pose estimate has been used in several previous research to extract aspects of human gait [9–15], but there is still a pressing need to compare these methods to concurrently acquired, gold-standard data.

Since this work is reconstruction of existing program, the original work is possible to found out in [1].

3 Methodology

In order to complete the task, first we did pose estimation, then we connected the points, and in the end we implemented the image matching detector.

3.1 Pose Estimation

Finding the location and orientation of a person or object is the goal of the challenging Computer Vision issue known as pose estimation. When referring to human position, this is typically accomplished by predicting the location of particular keypoints, such as hands, facial features, etc.

A comparison of the widely used specialized systems, including MediaPipe, OpenPose, and Yolo, was done in order to enhance the program with the capability of detecting human body landmarks. The best system was then applied.

Comparison Firstly, due to the numerous difficulties the approach encountered, the landmark detection results utilizing OpenPose were generally positive and encouraging yet unsatisfactory: The first step in using OpenPose was to evaluate earlier versions of the library that were still readily available. Second, compared to MediaPipe, using OpenPose was extremely slow. Processing videos requires a lot of computational power and takes a long time [16].

When compared to YOLOv7, MediaPipe is seen to perform better on low-resolution inputs, and it is faster than YOLOv7 on CPU inference. Furthermore, MediaPipe performs comparably well in locating distant objects or people. While

YOLOv7 can simultaneously detect numerous people, MediaPipe can only detect a single person. However, our data represent videos with only one person [19].

Therefore, we decided to use MediaPipe in our project.

MediaPipe MediaPipe Posture [20] is a machine learning (ML) solution for high-fidelity body pose tracking that displays 33 3D landmarks and a background segmentation mask on the entire body from RGB frames using BlazePose topology - a superset of COCO, BlazeFace, and BlazePalm topology shown in figure 4.1.

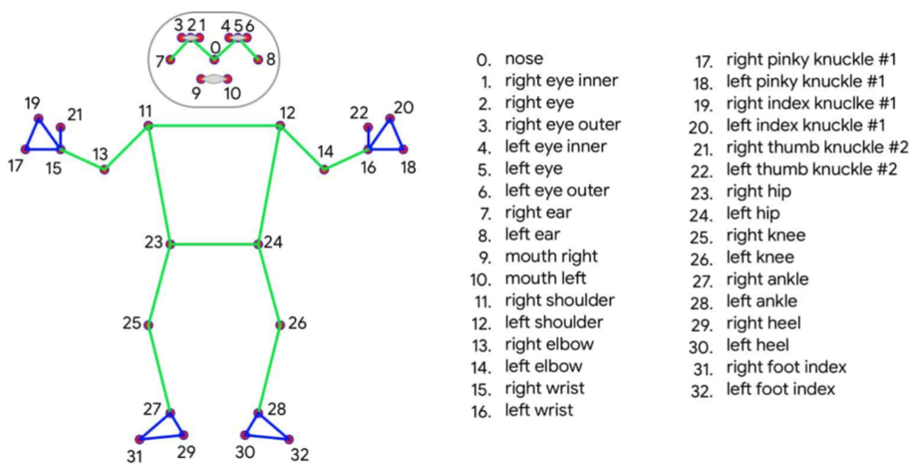


Fig. 1. BlazePose 33 keypoint topology as COCO (colored with green) superset [21]

3.2 Matching techniques

Fast and robust image matching is a crucial task with many uses in robotics and computer vision. We analyzed the performance of three alternative image matching approaches, namely SIFT, SURF, and ORB, before determining which one to use. We found that ORB is the fastest algorithm and that it obtains keypoints more efficiently than the other two. SURF is no longer in use today. Although SIFT does excellent job, the ORB produces superior outcomes.

ORB detector(Orientated FAST and Robust BRIEF) [17] - a fusion of the FAST key point detector and BRIEF descriptor with some modifications[18]. The top N points are then determined using the Harris corner measure. FAST is rotation-variant and does not compute orientation. It calculates the patch's intensity-weighted centroid with the corner at the center. The orientation is determined by the vector's direction from this corner point to the centroid. In order to increase rotational invariance, moments are computed. There is a poor performance of the descriptor BRIEF in an in-plane rotation. In ORB, a rotation matrix is created using the patch's orientation, and the BRIEF descriptors are then directed in accordance with that matrix.

4 Experiments

The assignment was carried out on videos provided by the assistant for the course. In each video, there is a person walking on a treadmill. Initially, we took two videos and converted them from BGR to RGB. Then we checked if there was a JSON file for each of those two videos, in which the point's coordinates were stored. If yes, we take points from there; if not, we capture points, and in the end, we save them in a JSON file for future usage. We displayed points and merged the two videos into one so that the suitable points from both videos could be connected. The ORB detector was then used to detect and compute features as well as draw matches between discovered features. Code is available on github [22] and the result of the assignment is shown in the figure below.

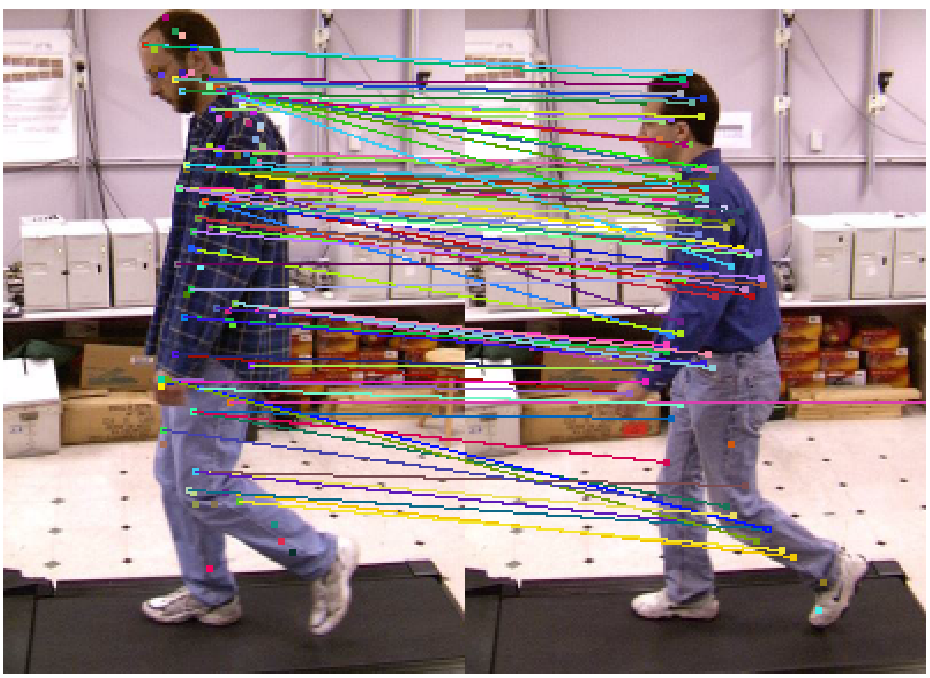
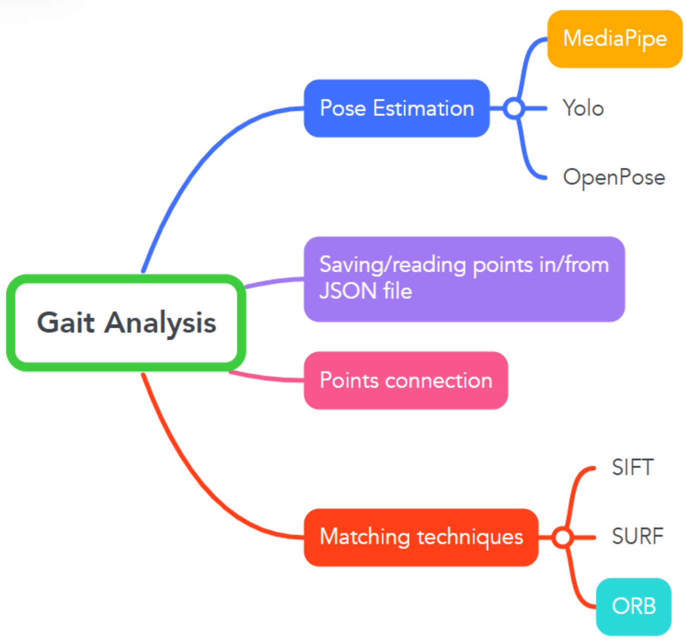


Fig. 2. Gait analysis.

4.1 Mind Map



References

1. Author, Narvika Bovcon T.: Umetnost v svetu pametnih strojev: novomedijska umetnost Sreča Dragana, Jake Železnikarja in Marka Peljhana (2009)., pp. 166-171, ISBN.: 978-961-91062-9-7
2. Baker R. The history of gait analysis before the advent of modern computers. Gait Posture. 2007;26(3):331–42. pmid:17306979
3. Andriluka M, Pishchulin L, Gehler P, Schiele B. 2D Human Pose Estimation: New Benchmark and State of the Art Analysis. 2014 IEEE Conference on Computer Vision and Pattern Recognition; 23–28 June 2014.
4. Cao Z, Hidalgo G, Simon T, Wei SE, Sheikh Y. OpenPose: Realtime Multi-Person 2D Pose Estimation Using Part Affinity Fields. IEEE transactions on pattern analysis and machine intelligence. 2021;43(1):172–86. pmid:31331883
5. Insafutdinov E, Pishchulin L, Andres B, Andriluka M, Schiele B. DeeperCut: A Deeper, Stronger, and Faster Multi-person Pose Estimation Model. Computer Vision–ECCV 2016; 2016.
6. Pishchulin L, Insafutdinov E, Tang S, Andres B, Andriluka M, Gehler P, et al. DeepCut: Joint Subset Partition and Labeling for Multi Person Pose Estimation. 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR); 27–30 June 2016.

7. Martinez J, Hossain R, Romero J, Little JJ. A Simple Yet Effective Baseline for 3d Human Pose Estimation. 2017 IEEE International Conference on Computer Vision (ICCV); 22–29 Oct. 2017.
8. Toshev A, Szegedy C. DeepPose: Human Pose Estimation via Deep Neural Networks. 2014 IEEE Conference on Computer Vision and Pattern Recognition; 23–28 June 2014
9. Kidziński Ł, Yang B, Hicks JL, Rajagopal A, Delp SL, Schwartz MH. Deep neural networks enable quantitative movement analysis using single-camera videos. Nature Communications. 2020;11(1):4054. pmid:32792511
10. Sato K, Nagashima Y, Mano T, Iwata A, Toda T. Quantifying normal and parkinsonian gait features from home movies: Practical application of a deep learning–based 2D pose estimator. PLOS ONE. 2019;14(11):e0223549. pmid:31725754
11. D'Antonio E, Taborri J, Palermo E, Rossi S, Patanè F. A markerless system for gait analysis based on OpenPose library. 2020 IEEE International Instrumentation and Measurement Technology Conference (I2MTC); 25–28 May 2020.
12. Chambers C, Kong G, Wei K, Kording K. Pose estimates from online videos show that side-by-side walkers synchronize movement under naturalistic conditions. PLOS ONE. 2019;14(6):e0217861. pmid:31170214
13. Viswakumar A, Rajagopalan V, Ray T, Parimi C. Human Gait Analysis Using OpenPose. 2019 Fifth International Conference on Image Information Processing (ICIIP); 15–17 Nov. 2019.
14. Ong A, Harris IS, Hamill J. The efficacy of a video-based marker-less tracking system for gait analysis. Computer Methods in Biomechanics and Biomedical Engineering. 2017;20(10):1089–95. pmid:28569549
15. Sandau M, Koblauch H, Moeslund TB, Aanæs H, Alkjær T, Simonsen EB. Markerless motion capture can provide reliable 3D gait kinematics in the sagittal and frontal plane. Medical Engineering Physics. 2014;36(9):1168–75.
16. https://www.hearai.pl/post/14-openpose/. Last accessed 4 Jan 2023
17. Author, Karami E., Author, Prasad S., Author, Shehata M.: Image Matching Using SIFT, SURF, BRIEF and ORB: Performance Comparison for Distorted Images(2017),
18. Author, Calonder M., Author, Lepetit V., Author, Strecha C., Author, Fua P.: BRIEF: Binary Robust Independent Elementary Features. In: Editor, Daniilidis K., Editor, Maragos P.,Editor, Paragios N.: Computer Vision – ECCV 2010, pp. 778–792. Springer, Berlin Heidelberg (2010). ISBN.: 978-3-642-15561-1
19. https://learnopencv.com/yolov7-pose-vs-mediapipe-in-human-pose-estimation/. Last accessed 4 Jan 2023
20. https://google.github.io/mediapipe/solutions/pose.html. Last accessed 4 Jan 2023
21. https://learnopencv.com/building-a-body-posture-analysis-system-using-mediapipe/. Last accessed 4 Jan 2023
22. https://github.com/mm9136/gaitRecognition. Last accessed 14 Jan 2023