

Accurate video tracking of indoor cycling races

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Abstract

We present a computer vision method combining accurate field calibration and innovative localization algorithm, enabling to provide automatically the precise trajectory of cyclists on a track race hence allowing quantitative analyses, including power production estimates based on the measured trajectory combined with a physical model.

Keywords

tracking; video; indoor cycling; localization; race modelling

1 Introduction

In some track cycling competitions, such as the 200-meter flying start, team pursuit, or team sprint, the trajectory followed by athletes during the race is essential to performance. In team events in particular, the power gain associated with collective effects depends heavily on how the team strategy is defined. Video analysis tools for analyzing the trajectories followed have therefore become indispensable for improving performance [1].

Furthermore, while watching a video of a race can already teach us a lot, knowing the position of athletes in real space over time, obtained with sufficient precision to

allow derivation and thus obtain speed and acceleration, is an additional step in training tools. What's more, such analysis applied to competitors' races also provides valuable information.

The prospect of being able to perform high-precision video tracking using either two fixed cameras or even one single camera following the athletes during the race, in any velodrome, is therefore particularly attractive. In this work, we describe the steps of an automatic tracking method we developed, as well as the possible outcome of such a tracking in terms of race analysis.



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2 Calibration

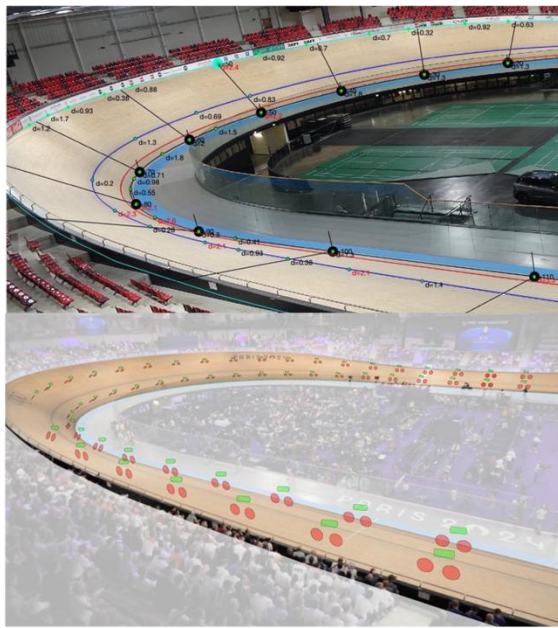


Figure 1. (Top) Image from a fixed camera, superimposed with the velodrome geometry obtained by the calibration method. (Bottom) 3D model of the cyclist, placed everywhere on the track using the calibration matrix.

The first crucial step of such a process is to determine, for each camera (filming one half of the velodrome from a fixed position and with a fixed orientation), the projection matrix that groups together information such as the camera's position and orientation in 3D space and its optical settings. This matrix allows for the position of points in real space to be converted into their projection in the image (in pixels) and vice-versa. It is usually determined from reference points whose 3D location is known. However, unlike most sports fields, which have a flat surface and known dimensions, the 3D geometry of a velodrome is not flat, varies slightly from one velodrome to another and is not known a priori. We therefore developed an optimization algorithm that allows us to extract both the projection matrices (associated with the cameras) and the specific geometry of the velodrome being observed (Figure 1, top). This algorithm has

also been extended to the situation where one single camera follows the cyclists during a race, instead of 2 fixed cameras.

3 Detection and Localization of cyclists

Using a single 3D model of a cyclist (defined as two circular wheels and a cylindrical torso), and the projection matrix obtained during the calibration stage, we can predict how a cyclist will appear on each camera based on their 3D position in the velodrome (Figure 1, bottom). By convoluting these virtual images with the acquired image, we can automatically detect one (or more) cyclists and locate them accurately. Analyzing the detections obtained from all the images in a video allows us to extract the trajectory of each cyclist. We validate our method by comparing the trajectories obtained with those from the independent multi-cameras tracking system installed at the French National Velodrome in Saint-Quentin-en-Yvelines. A complementary method of tracking based on machine learning (YOLOv8-Nano Pose model) is currently being developed in order to improve the cyclist localization. Key points of the cyclist are well identified by this model: wheel-ground contact points, wheel centers, cyclist head and hip.

4 Analysis Examples

Our tracking method enables information previously recorded “manually” by the team's analysts to be extracted automatically (such as maximum speed of a relay rider, maximum distance between cyclists in team sprint, etc.). The continuous nature of the information generated also enables new analyses (such as comparing dives in 200-meter sprints,

measuring the quality of drafting in team races) thus opening to new performance criteria. Furthermore, access to data on a cyclist's position over time (and therefore their speed and acceleration) does, under certain conditions, enable a physical model [2] to estimate the power output of the cyclist being filmed, which fits very well the output of the cyclist power sensor (Figure 2).

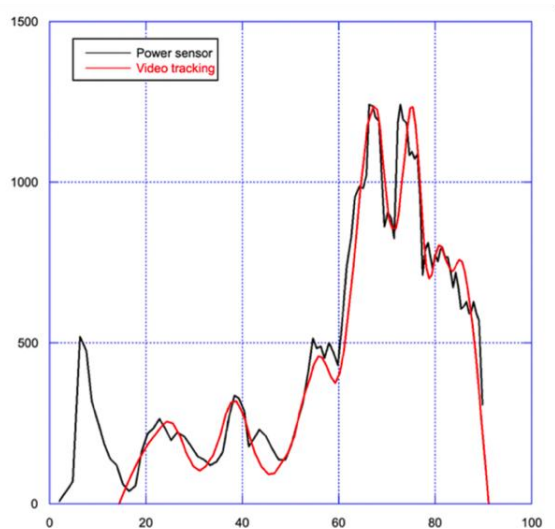


Figure 2. Comparison of power output estimated

from our tracking + physical model and by the cyclist power sensor. (Flying 200-m race)

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References

1. Decorte R., Verstockt S., & Slembrouck M. (2024). Multi-sensor based analysis of the changeovers in team pursuit. *Journal of Science and Cycling*, 13(2):33–38.
2. Clanet C., Odier P., Pottier B., & Brunet E. (2025). Equations of motion of a track cyclist: Active particle dynamics under strong geometric constraints. *Phys. Rev. E*, 112:044222. doi :10.1103/vm6w-d487