

# SoccerCPD : Formation and Role Change-Point Detection in Soccer Matches Using Spatiotemporal Tracking Data

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Figure 1: Place Holder Image

## Abstract

A clear and well-documented L<sup>A</sup>T<sub>E</sub>X document is presented as an article formatted for publication by ACM in a conference proceedings or journal publication. Based on the “acmart” document class, this article presents and explains many of the common variations, as well as many of the formatting elements an author may use in the preparation of the documentation of their work.

## Keywords

Do, Not, Use, This, Code, Put, the, Correct, Terms, for, Your, Paper

## 1 Introduction

ACM’s consolidated article template, introduced in 2017, provides a consistent L<sup>A</sup>T<sub>E</sub>X style for use across ACM publications, and incorporates accessibility and metadata-extraction functionality necessary for future Digital Library endeavors. Numerous ACM and SIG-specific L<sup>A</sup>T<sub>E</sub>X templates have been examined, and their unique features incorporated into this single new template.

If you are new to publishing with ACM, this document is a valuable guide to the process of preparing your work for publication. If you have published with ACM before, this document provides insight and instruction into more recent changes to the article template.

The “acmart” document class can be used to prepare articles for any ACM publication — conference or journal, and for any stage of publication, from review to final “camera-ready” copy, to the author’s own version, with *very few changes* to the source.

## 2 Formation Change-Point Detection (FormCPD)

### 3 Role Change-Point Detection (RoleCPD)

#### 3.1 Methodology

The goal of RoleCPD [1] is to detect long-term tactical changes in player roles (e.g., a winger swapping sides with another winger permanently) while ignoring temporary switches (e.g., overlapping runs or covering defensive duties). This process operates within a single Formation Period ( $T_i$ ) identified in the previous step.

#### 3.2 Formal Representation

We define the inputs and mathematical framework based on the SoccerCPD protocol:

- **Input:** A sequence of "Temporary Role Permutations"  $\{\pi_t\}_{t=1}^{|T_i|}$ .
- **Role Permutation ( $\pi_t$ ):** At every frame  $t$ , the Role Representation step assigns a role  $X_p$  to every player  $p$ . Since roles are distinct, this assignment is a permutation of the initial canonical role:

$$\beta_t(p) = \pi_t(X_p)$$

Where  $\beta_t$  is the player-to-temporary-role mapping at time  $t$ .

#### 3.3 The Distance Metric

To detect a change, we must quantify the difference between the team’s configuration at time  $t$  and time  $t'$ . Since the data consists of permutations (non-Euclidean), we cannot use standard Euclidean distance. We use the Hamming Distance normalized by the number of roles ( $N = 10$  outfield players):

$$d(\pi_t, \pi_{t'}) = \frac{1}{N} \sum_{p \in P} \mathbb{1}_{\pi_t(X_p) \neq \pi_{t'}(X_p)}$$

This metric represents the "Switch Rate" or the proportion of players whose roles differ between two frames.

#### 3.4 Change-Point Detection Algorithm

The paper utilizes Discrete g-segmentation, a graph-based change-point detection method effective for repeated observations in non-Euclidean space. The procedure is as follows:

- (1) **Preprocessing:** Calculate the Switch Rate relative to the dominant permutation. Exclude frames with a switch rate > 0.7 (likely temporary switches during set-pieces or abnormal situations).
- (2) **Segmentation:** Apply the detection algorithm recursively on the sequence of permutations using the Hamming distance.
- (3) **Significance Test:** A change point  $\tau$  is significant if:
  - The p-value of the scan statistic is < 0.01.
  - The segmentation duration is sufficient (robustness against noise).

- The most frequent permutations (Instructed Roles) in the segments before and after  $\tau$  must be distinct.

## References

- [1] Hyunsung Kim, Bit Kim, Dongwook Chung, Jinsung Yoon, and Sang-Ki Ko. 2022. SoccerCPD: Formation and Role Change-Point Detection in Soccer Matches Using Spatiotemporal Tracking Data. In *The 28th ACM SIGKDD Conference on Knowledge Discovery and Data Mining*. ACM, 3146–3156. doi:10.1145/3534678.3539150