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

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Hyunsung Kim
Fitogether Inc.
Seoul, South Korea

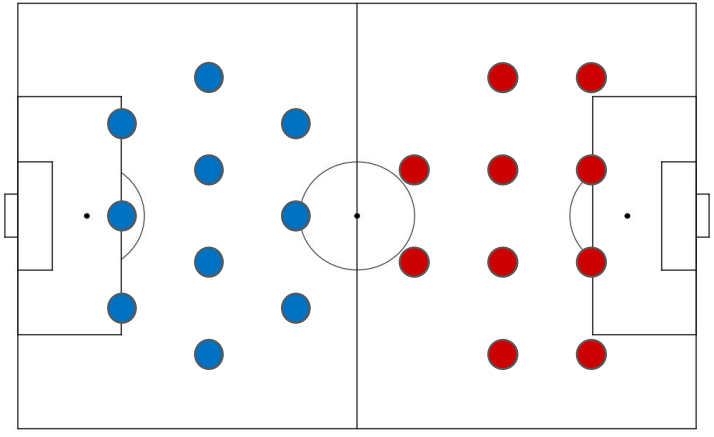
Bit Kim
Fitogether Inc.
Seoul, South Korea

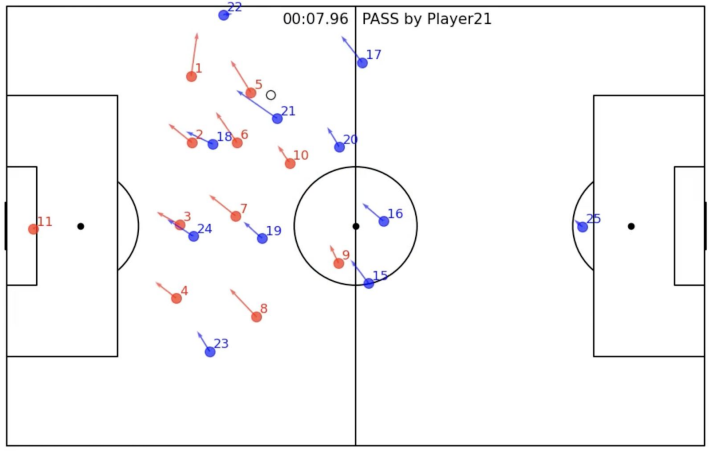
Dongwook Chung
Fitogether Inc.
Seoul, South Korea

Jinsung Yoon
Fitogether Inc.
Seoul, South Korea

Sang-Ki Ko
Kangwon Nat'l Univ.
Chuncheon, South Korea

Introduction: Formation and role estimation in team sports

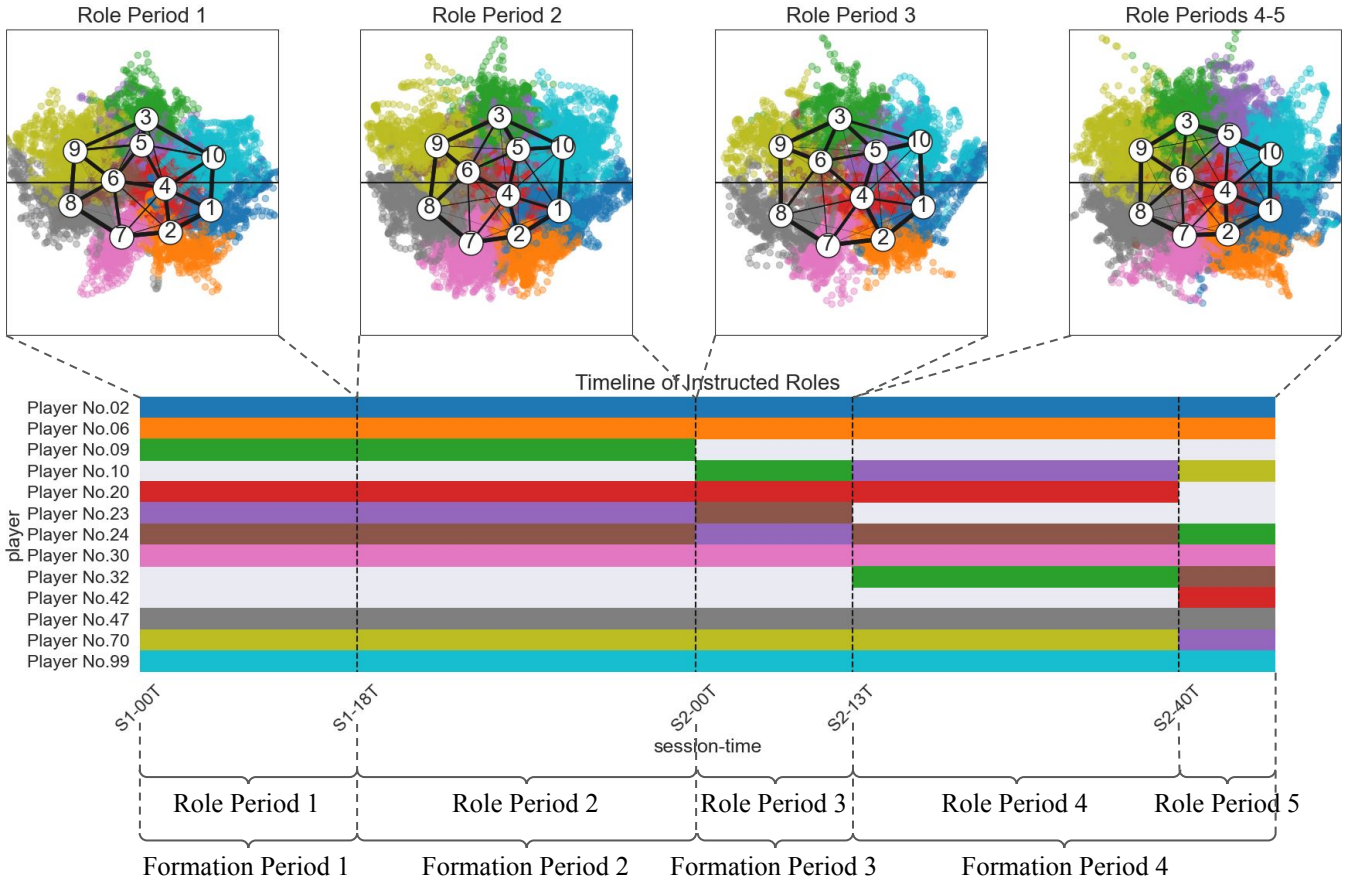




Technical challenges

- Coaches initially assign a unique role to each player, but **they can change their instruction** throughout the match.
- **Players temporarily switch their roles** with their teammates.
- **Abnormal situations** such as set-pieces sometimes occur, in which all the players ignore the team formation.

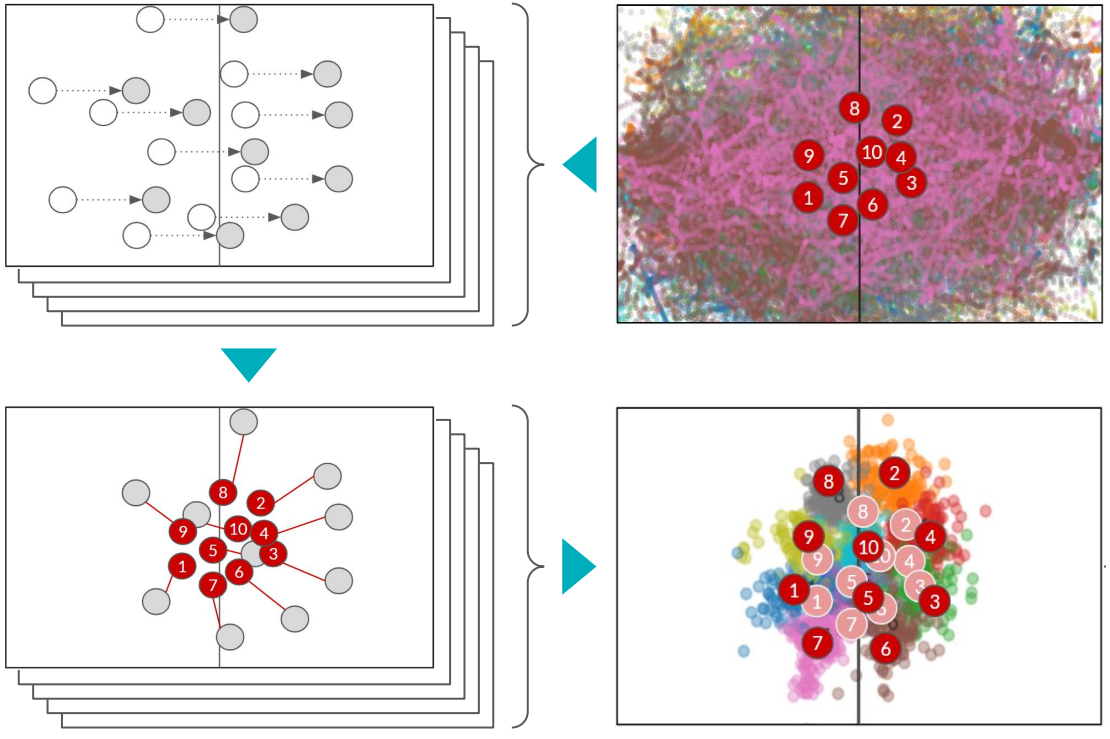
Overview of the whole framework



Frame-by-frame player-role assignment

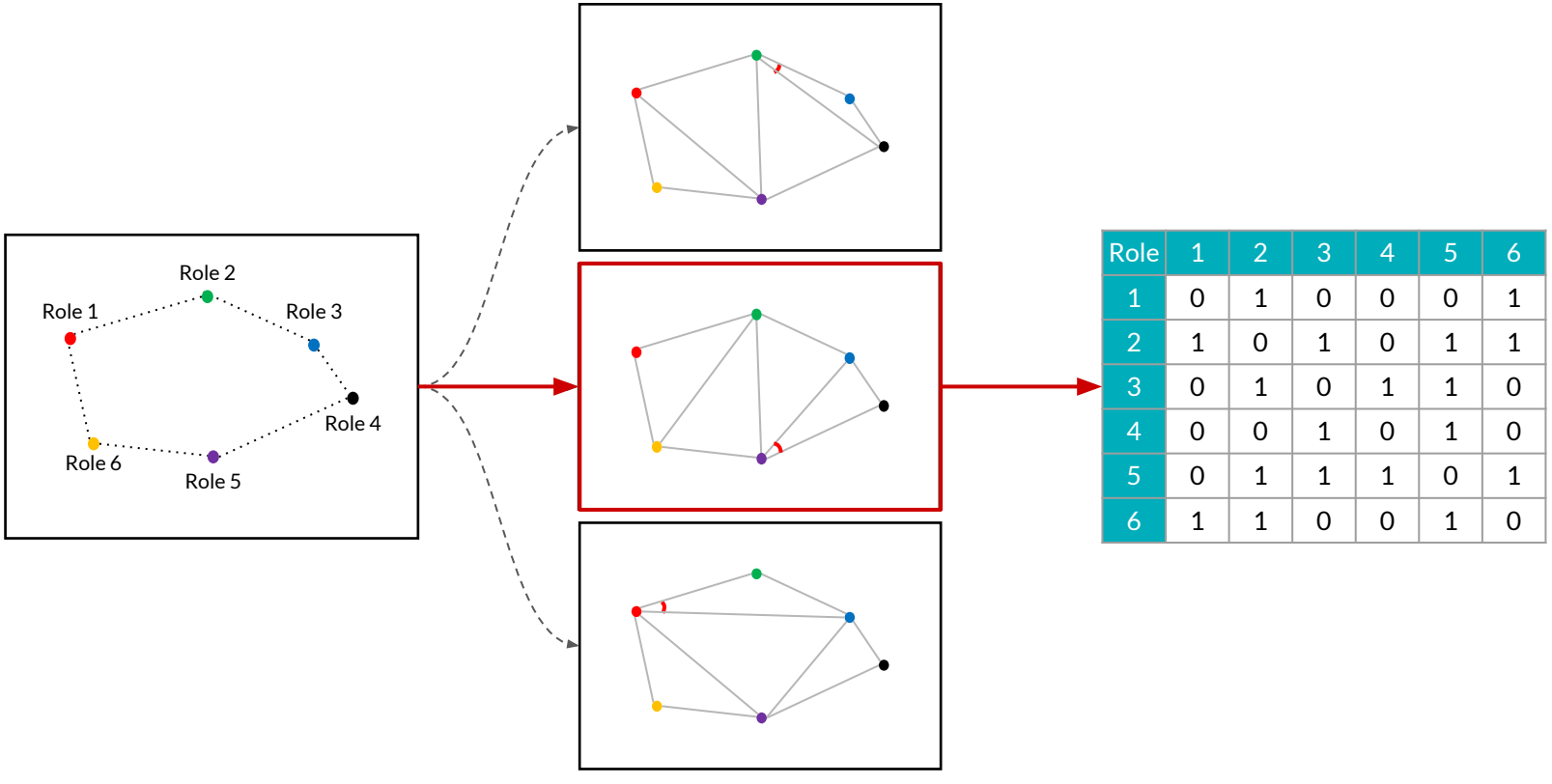
Large-Scale Analysis of Soccer Matches Using Spatiotemporal Tracking Data

Bialkowski et al. (ICDM 2014)



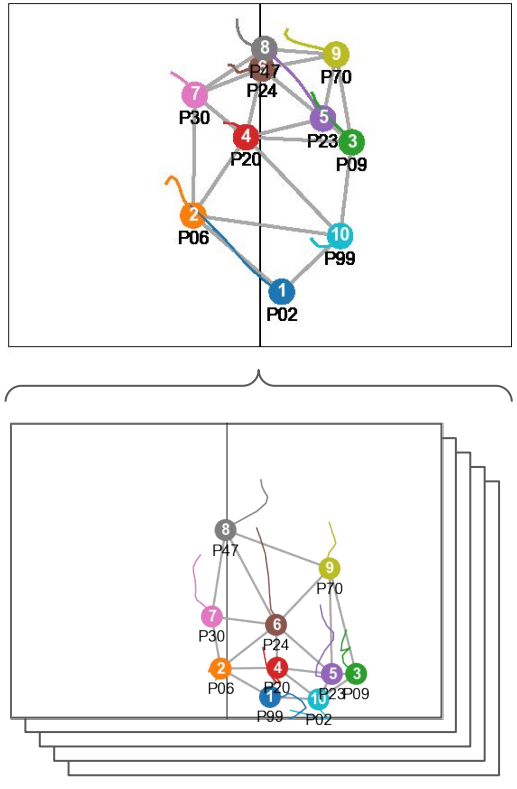
Time	Player A	Player B	Player C	...	Player J
1	Role 1	Role 3	Role 2	...	Role 10
2	Role 1	Role 3	Role 2	...	Role 10
3	Role 10	Role 3	Role 2	...	Role 1
...	...	...	...	...	...
2700	Role 10	Role 2	Role 3	...	Role 1

Step 1-1: Representation of players' spatial configuration



Role	1	2	3	4	5	6
1	0	1	0	0	0	1
2	1	0	1	0	1	1
3	0	1	0	1	1	0
4	0	0	1	0	1	0
5	0	1	1	1	0	1
6	1	1	0	0	1	0

Step 1-1: Representation of players' spatial configuration

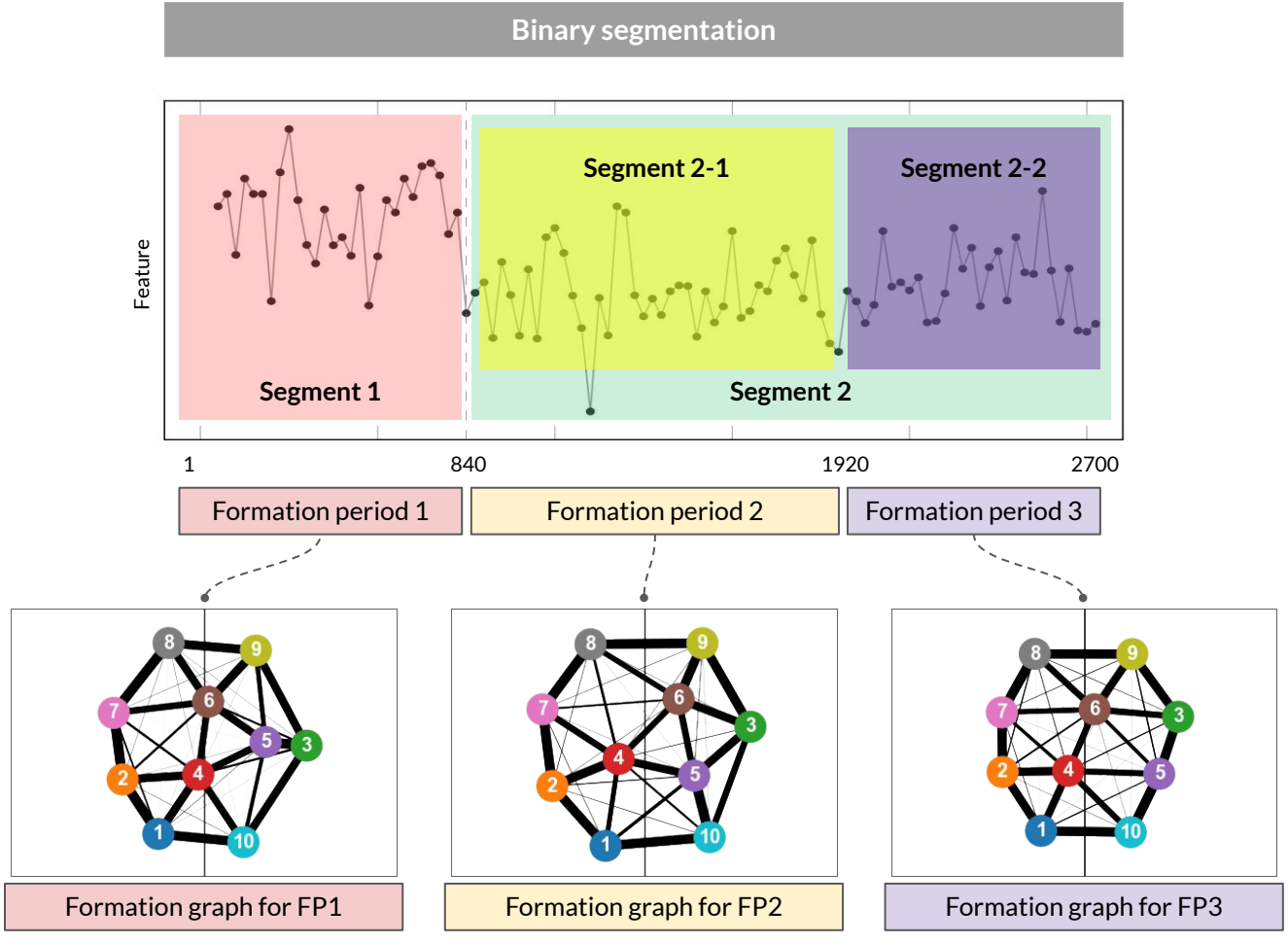


Seq. of Delaunay graphs

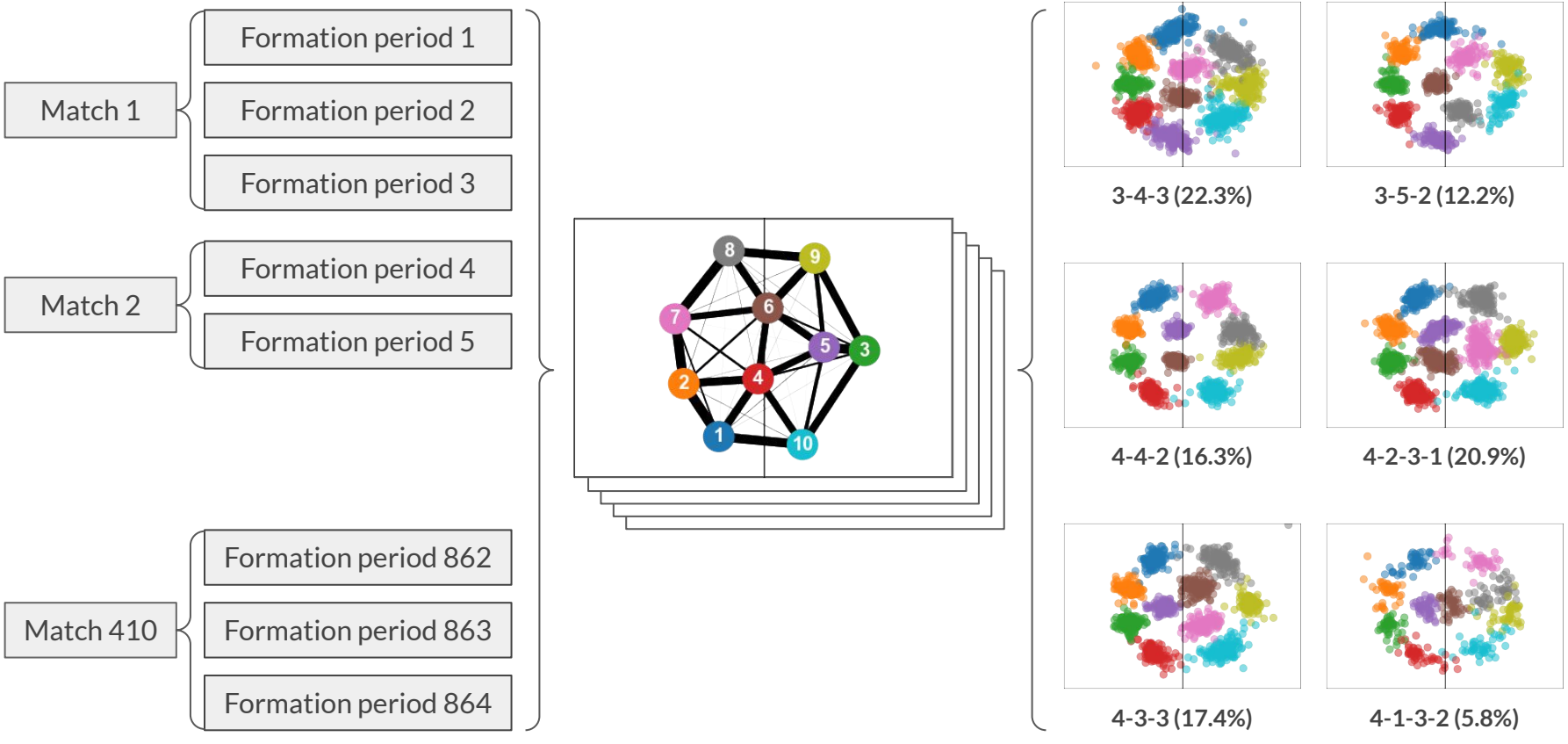
Role	1	2	3	4	...	10
1	0	1	0	1	...	1
2	1	0	0	0	...	0
3	0	0	0	1	...	1
4	1	0	1	0	...	1
...	...	...	...	...	...	...
10	1	0	1	1	...	0

Seq. of role-adjacency matrices

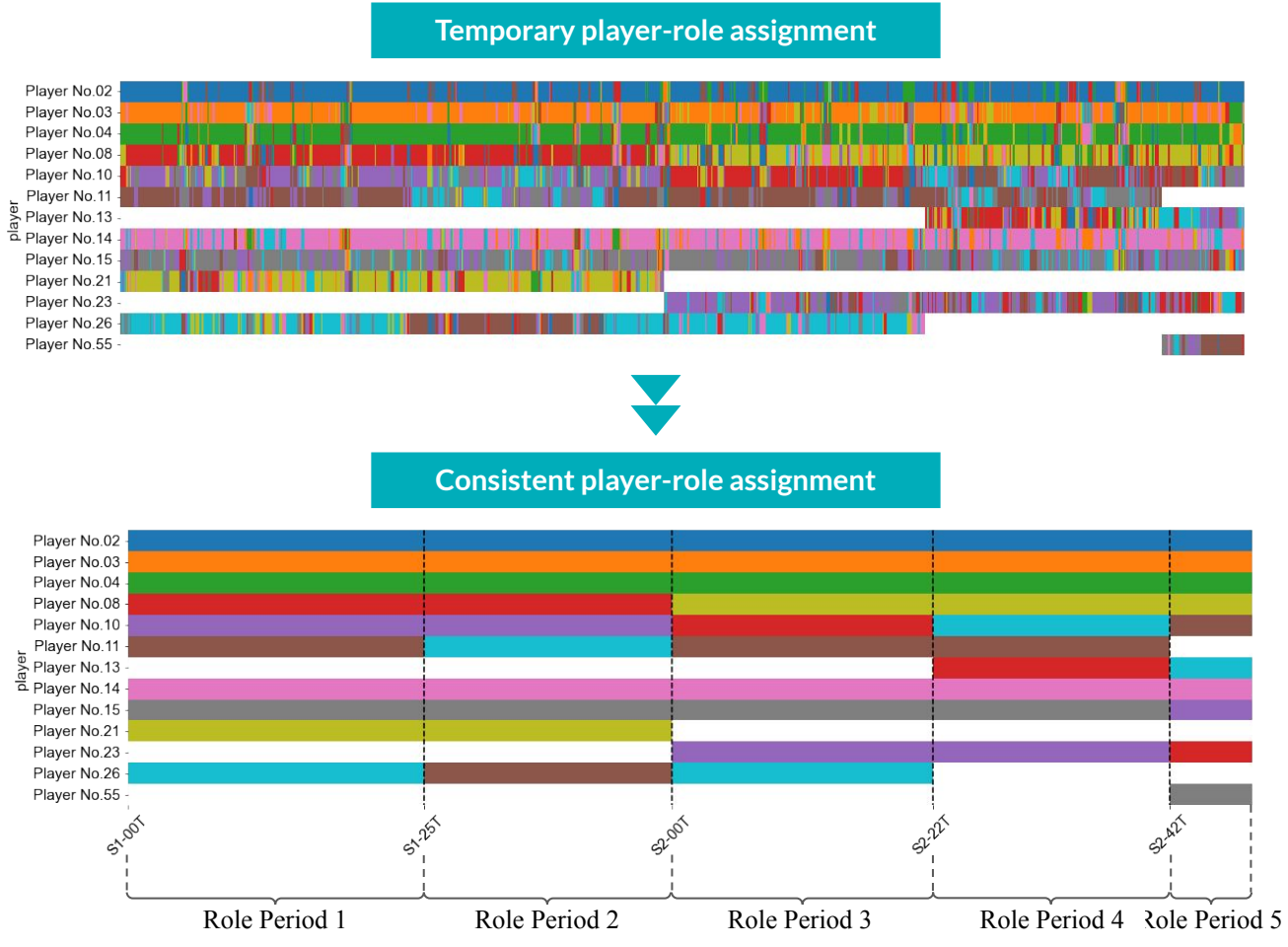
Step 1-2: Formation change-point detection



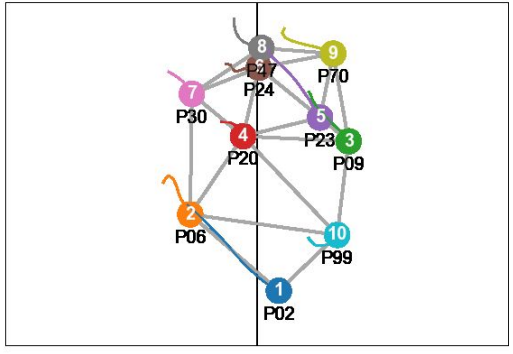
Step 1-3: Formation clustering

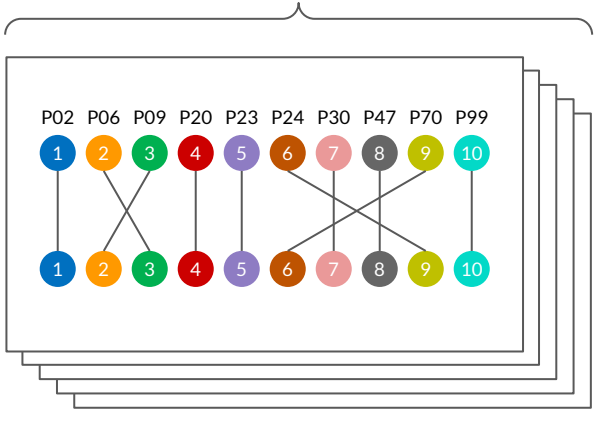


Overview of role change-point detection



Step 2-1: Representation of player transposition





Time	Role 1	Role 2	Role 3	...	Role 10
1	Role 1	Role 3	Role 2	...	Role 10
2	Role 1	Role 3	Role 2	...	Role 10
3	Role 10	Role 3	Role 2	...	Role 1
...	...	...	...	...	...
2700	Role 10	Role 2	Role 3	...	Role 1

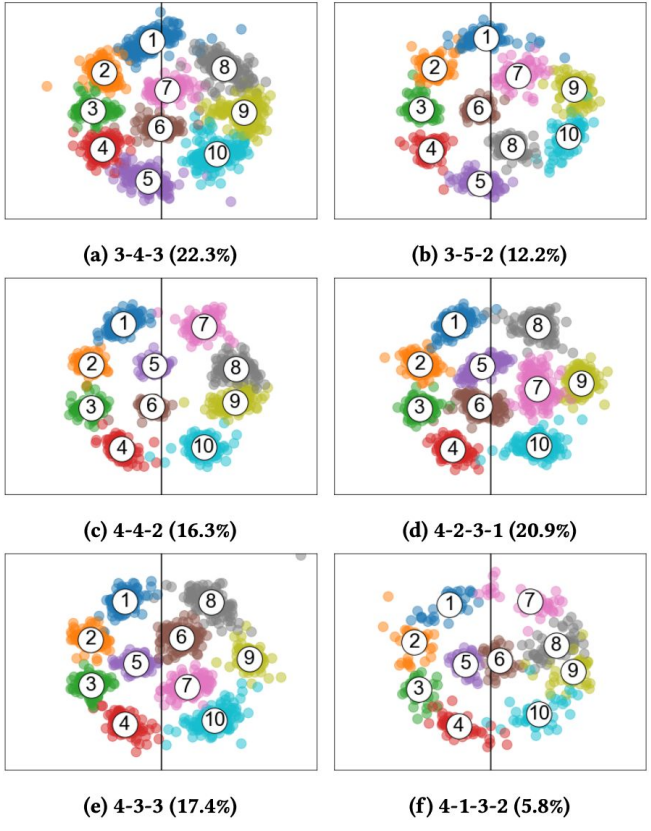
Seq. of player-role assignments

Seq. of role permutations

Step 2-2: Role change-point detection

Step 2-3: Rule-based position labeling

Formation clusters



(a) 3-4-3 (22.3%)

(b) 3-5-2 (12.2%)

(c) 4-4-2 (16.3%)

(d) 4-2-3-1 (20.9%)

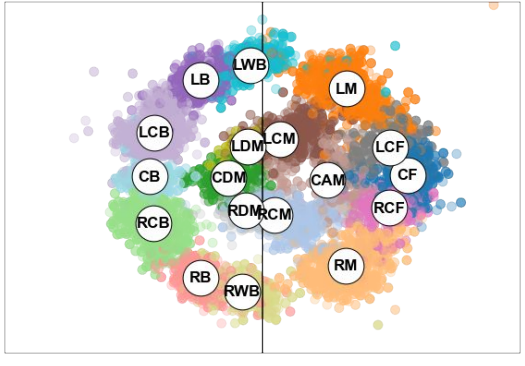
(e) 4-3-3 (17.4%)

(f) 4-1-3-2 (5.8%)

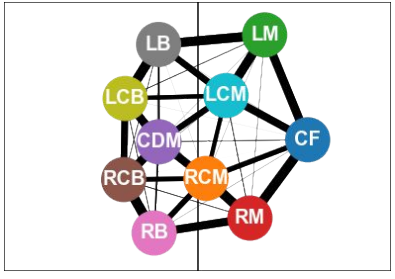
Assignment rules of position labels

Role	3-4-3	3-5-2	4-4-2	4-2-3-1	4-3-3	4-1-3-2
1	LWB	LWB	LB	LB	LB	LB
2	LCB	LCB	LCB	LCB	LCB	LCB
3	CB	CB	RCB	RCB	RCB	RCB
4	RCB	RCB	RB	RB	RB	RB
5	RWB	RWB	LCM	LDM	CDM	CDM
6	RCM	CDM	RCM	RDM	LCM	CAM
7	LCM	LCM	LM	CAM	RCM	LM
8	LM	RCM	LCF	LM	LM	LCF
9	CF	LCF	RCF	CF	CF	RCF
10	RM	RCF	RM	RM	RM	RM

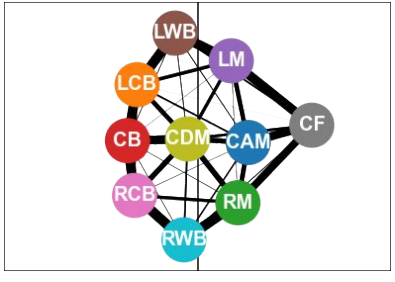
Role scatterplot colored by position



Examples of labeled positions

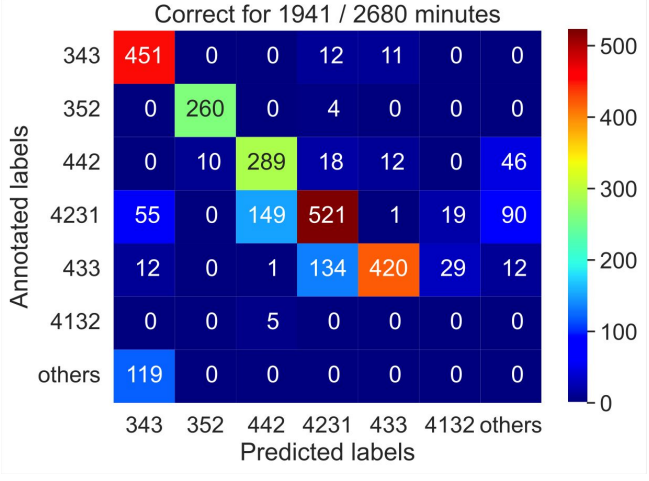


Formation “4-3-3”

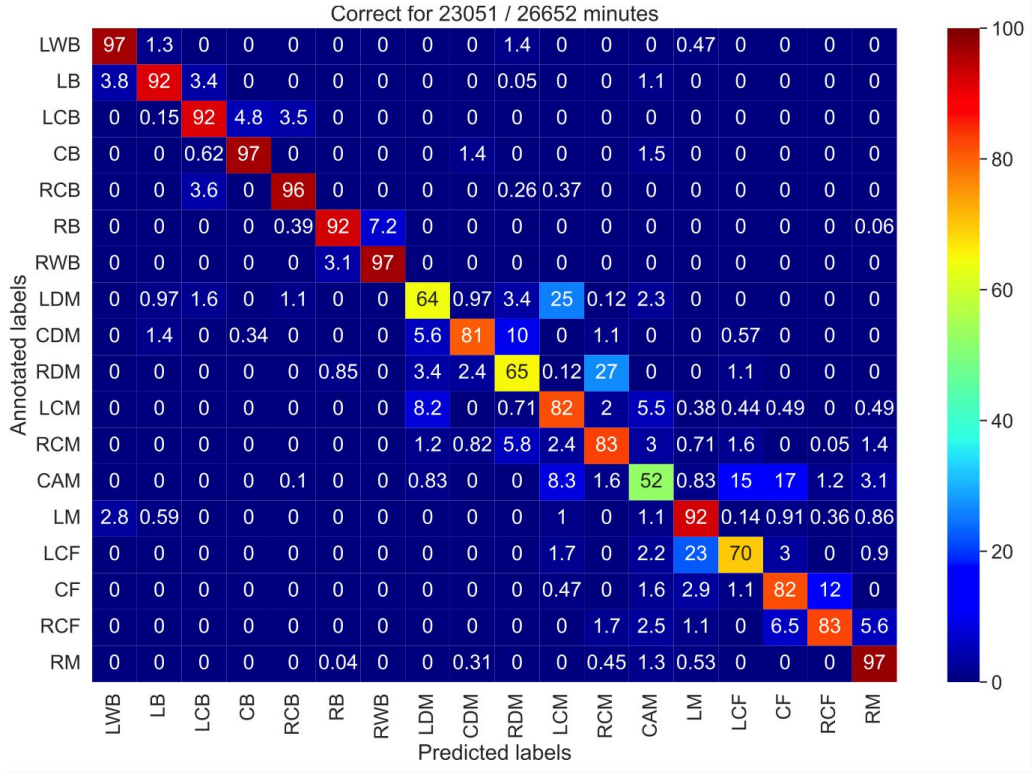


Formation “others”

Experiment 1: Model evaluation

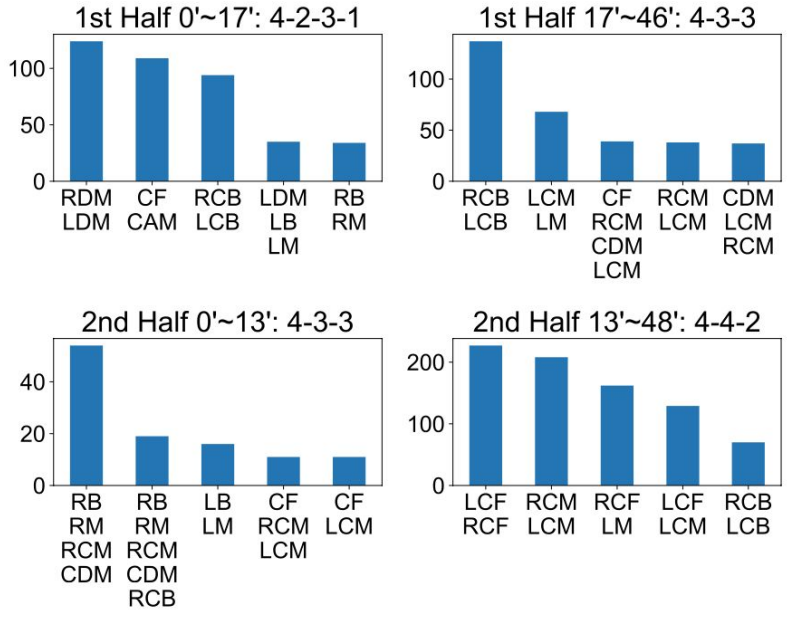


Formation prediction accuracy in minute

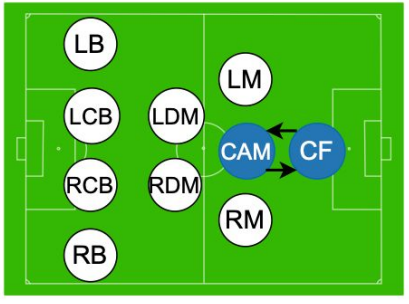


Position prediction accuracy in percentage

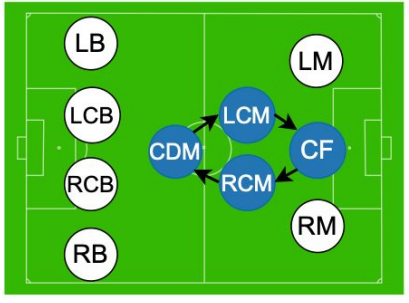
Experiment 2: Switching pattern detection



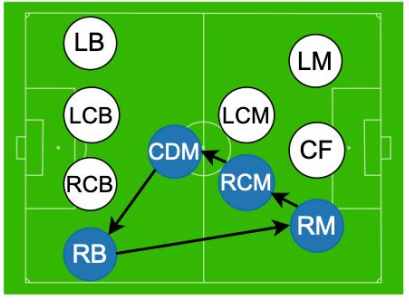
(a) Histograms of top-5 frequent cycles in second.



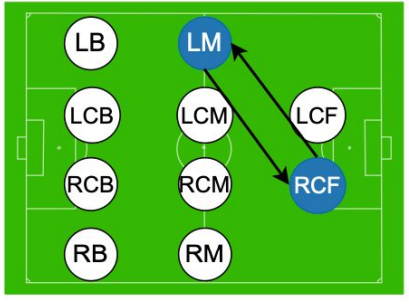
(b) False-nine play in FP1



(c) False-nine play in FP2



(d) Fullback overlap in FP3



(e) Cutting inside in FP4

Conclusion

Contributions

- effectively representing **team formations** and **role switches** in soccer as adjacency matrices and permutations
- detecting their **change-points** by applying a SOTA CPD method
- proposing **switching play detection** and **set-piece detection** as applications
- releasing a **Python implementation** of our framework with **sample GPS data**

Limitations

- not taking the **offensive/defensive contexts** into account
- confusing the formations with **similar spatial configurations** (4-2-3-1 vs 4-4-2)
- only assigning labels to popular formations and classifying **irregular formations** into the group “others”

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Thank you for listening!

Personal Website

Contact information

Hyunsung Kim (1st author): hyunsung.kim@fitogether.com

Jinsung Yoon (CEO@Fitogether): jinsung.yoon@fitogether.com

Source Code

KDD 2022

Fitogether