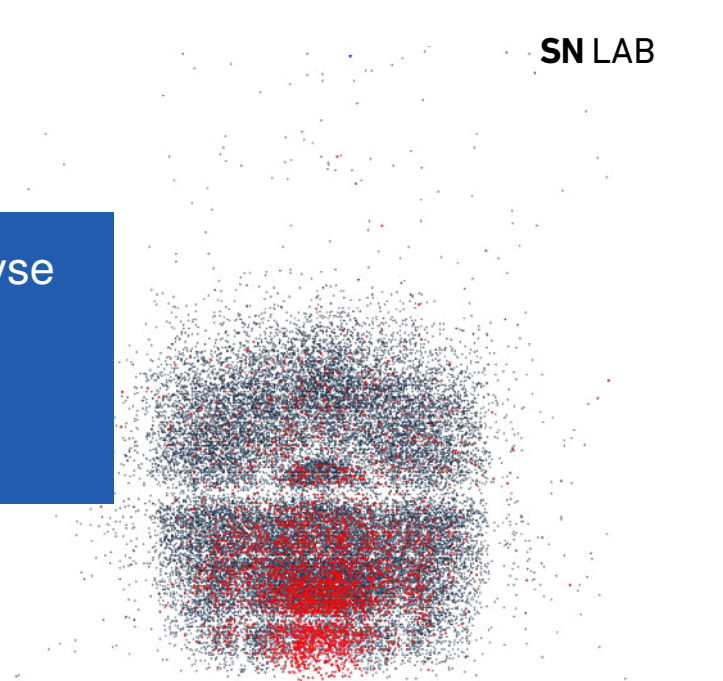


Fussballdatenanalyse

Ulrik Brandes, ETH Zürich

Bodensee Wirtschaftsforum
Thurgauer Wirtschaftsinstitut
11. Mai 2022



Sportdaten

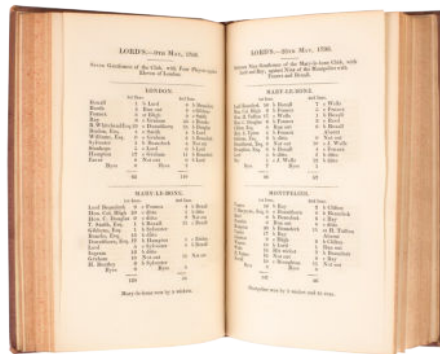
ermöglicht durch **Kodifizierung** (verschriftlichtes Regelwerk)

- Tennis (*jeu de paume*)
- Golf
- Cricket (*club-ball*)
- Baseball (*rounders*)

schrittweise Ausdehnung der Nutzung

- **Spielstände**
- Berichterstattung
- Talentsichtung
- **Analyse**

Ergebnis $\neq$ Leistung (was $\neq$ wie)



Bentley (1823). *A Correct Account of All the Cricket Matches Which Have Been Played by the Mary-le-bone Club, and all other Principal Matches From the Year 1786 to 1822 Inclusive.* T. Traveller

Spielregeln

2021/2022

1. Spielfeld	<i>Raum</i>
2. Ball	
3. Spieler	<i>Akteure</i>
4. Ausrüstung der Spieler	
5. Schiedsrichter	
6. Weitere Spieloffizielle	
7. Dauer des Spiels	<i>Zeit</i>
8. Beginn und Fortsetzung des Spiels	
9. Ball in und aus dem Spiel	
10. Bestimmung des Spielausgangs	<i>Ergebnis</i>
11. Abseits	<i>Übertritte</i>
12. Fouls und sonstiges Fehlverhalten	
13. Freistösse	<i>Standards</i>
14. Strafstoss	
15. Einwurf	
16. Abstoss	
17. Eckstoss	

Regel 2

“Der Ball ist rund” (Herberger)



Mindestanforderungen: kugelförmig mit

Umfang	68–70 cm	27–28 ins
Gewicht	410–450 g	14–16 oz
Druck	600–1100 g/cm ²	8.5–15.6 lbs/sq in

+ Zertifizierung und Authorisierung

Ein Markt rund um die Datenanalyse

Alamar (2013). *Sports Analytics*. Columbia University Press

Ziele

- Scouting
- Gegneranalyse
- Spiel- und Mannschaftsanalyse
- Berichterstattung
- Wettquoten und Dienstleistungen
- Gaming

Beteiligte

- Datenlieferanten und Beratungsfirmen
- Vereine und Verbände
- Medien und Marken
- Wettanbieter, Spielehersteller, ...

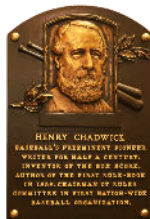


Baseball

Red Hook, CLUB OF COUNTRYMEN, 2nd Winter Meeting, March 22, 1887

BATSMAN	NO.	1	2	3	4	5	6	7	8	9	10	11	FIELDERS
Goodnight	15	1	2	3	4	5	6	7	8	9	10	11	52
Condit	16	1	2	3	4	5	6	7	8	9	10	11	42
Belmont	23	1	2	3	4	5	6	7	8	9	10	11	53
Albee	8	1	2	3	4	5	6	7	8	9	10	11	23
Wadsworth	9	1	2	3	4	5	6	7	8	9	10	11	52
Wheeler	10	1	2	3	4	5	6	7	8	9	10	11	25
Stannard	11	1	2	3	4	5	6	7	8	9	10	11	32
Sackett	22	1	2	3	4	5	6	7	8	9	10	11	13
Moore	20	1	2	3	4	5	6	7	8	9	10	11	02
TOTAL		0	2	7	4	0	3	8	0	0			2724

A. 1st ball down. B. 2nd ball down. C. 3rd ball down. D. 4th ball down. E. 5th ball down. F. 6th ball down. G. 7th ball down. H. 8th ball down. I. 9th ball down. J. 10th ball down. K. 11th ball down. L. 12th ball down. M. 13th ball down. N. 14th ball down. O. 15th ball down. P. 16th ball down. Q. 17th ball down. R. 18th ball down. S. 19th ball down. T. 20th ball down. U. 21st ball down. V. 22nd ball down. W. 23rd ball down. X. 24th ball down. Y. 25th ball down. Z. 26th ball down. AA. 27th ball down. AB. 28th ball down. AC. 29th ball down. AD. 30th ball down. AE. 31st ball down. AF. 32nd ball down. AG. 33rd ball down. AH. 34th ball down. AI. 35th ball down. AJ. 36th ball down. AK. 37th ball down. AL. 38th ball down. AM. 39th ball down. AN. 40th ball down. AO. 41st ball down. AP. 42nd ball down. AQ. 43rd ball down. AR. 44th ball down. AS. 45th ball down. AT. 46th ball down. AU. 47th ball down. AV. 48th ball down. AW. 49th ball down. AX. 50th ball down. AY. 51st ball down. AZ. 52nd ball down. BA. 53rd ball down. BB. 54th ball down. BC. 55th ball down. BD. 56th ball down. BE. 57th ball down. BF. 58th ball down. BG. 59th ball down. BH. 60th ball down. BI. 61st ball down. BJ. 62nd ball down. BK. 63rd ball down. BL. 64th ball down. BM. 65th ball down. BN. 66th ball down. BO. 67th ball down. BP. 68th ball down. BQ. 69th ball down. BR. 70th ball down. BS. 71st ball down. BT. 72nd ball down. BU. 73rd ball down. BV. 74th ball down. BW. 75th ball down. BX. 76th ball down. BY. 77th ball down. BZ. 78th ball down. CA. 79th ball down. CB. 80th ball down. CC. 81st ball down. CD. 82nd ball down. CE. 83rd ball down. CF. 84th ball down. CG. 85th ball down. CH. 86th ball down. CI. 87th ball down. CJ. 88th ball down. CK. 89th ball down. CL. 90th ball down. CM. 91st ball down. CN. 92nd ball down. CO. 93rd ball down. CP. 94th ball down. CQ. 95th ball down. CR. 96th ball down. CS. 97th ball down. CT. 98th ball down. CU. 99th ball down. CV. 100th ball down. CW. 101st ball down. CX. 102nd ball down. CY. 103rd ball down. CZ. 104th ball down. DA. 105th ball down. DB. 106th ball down. DC. 107th ball down. DD. 108th ball down. DE. 109th ball down. DF. 110th ball down. DG. 111th ball down. DH. 112th ball down. DI. 113th ball down. DJ. 114th ball down. DK. 115th ball down. DL. 116th ball down. DM. 117th ball down. DN. 118th ball down. DO. 119th ball down. DP. 120th ball down. DQ. 121st ball down. DR. 122nd ball down. DS. 123rd ball down. DT. 124th ball down. DU. 125th ball down. DV. 126th ball down. DW. 127th ball down. DX. 128th ball down. DY. 129th ball down. DZ. 130th ball down. EA. 131st ball down. EB. 132nd ball down. EC. 133rd ball down. ED. 134th ball down. EE. 135th ball down. EF. 136th ball down. EG. 137th ball down. EH. 138th ball down. EI. 139th ball down. EJ. 140th ball down. EK. 141st ball down. EL. 142nd ball down. EM. 143rd ball down. EN. 144th ball down. EO. 145th ball down. EP. 146th ball down. EQ. 147th ball down. 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WY. 618th ball down. WZ. 619th ball down. XA. 620th ball down. XB. 621st ball down. XC. 622nd ball down. XD. 623rd ball down. XE. 624th ball down. XF. 625th ball down. XG. 626th ball down. XH. 627th ball down. XI. 628th ball down. XJ. 629th ball down. XK. 630th ball down. XL. 631st ball down. XM. 632nd ball down. XN. 633rd ball down. XO. 634th ball down. XP. 635th ball down. XQ. 636th ball down. XR. 637th ball down. XS. 638th ball down. XT. 639th ball down. XU. 640th ball down. XV. 641st ball down. XW. 642nd ball down. XX. 643rd ball down. XY. 644th ball down. XZ. 645th ball down. YA. 646th ball down. YB. 647th ball down. YC. 648th ball down. YD. 649th ball down. YE. 650th ball down. YF. 651st ball down. YG. 652nd ball down. YH. 653rd ball down. YI. 654th ball down. YJ. 655th ball down. YK. 656th ball down. YL. 657th ball down. YM. 658th ball down. YN. 659th ball down. YO. 660th ball down. YP. 661st ball down. YQ. 662nd ball down. YR. 663rd ball down. YS. 664th ball down. 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EF. 806th ball down. EG. 807th ball down. EH. 808th ball down. EI. 809th ball down. EJ. 810th ball down. EK. 811th ball down. EL. 812th ball down. EM. 813th ball down. EN. 814th ball down. EO. 815th ball down. EP. 816th ball down. EQ. 817th ball down. ER. 818th ball down. ES. 819th ball down. ET. 820th ball down. EU. 821st ball down. EV. 822nd ball down. EW. 823rd ball down. EX. 824th ball down. EY. 825th ball down. EZ. 826th ball down. FA. 827th ball down. FB. 828th ball down. FC. 829th ball down. FD. 830th ball down. FE. 831st ball down. FF. 832nd ball down. FG. 833rd ball down. FH. 834th ball down. FI. 835th ball down. FJ. 836th ball down. FK. 837th ball down. FL. 838th ball down. FM. 839th ball down. FN. 840th ball down. FO. 841st ball down. FP. 842nd ball down. FQ. 843rd ball down. FR. 844th ball down. FS. 845th ball down. FT. 846th ball down. FU. 847th ball down. FV. 848th ball down. FW. 849th ball down. FX. 850th ball down. FY. 851st ball down. FZ. 852nd ball down. 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Henry Chadwick (1824–1908)

1856 Überlauf von Cricket

1859 **Box Score**

1860 Jahrbücher

1868 Regelbuch

1938 Ruhmeshalle

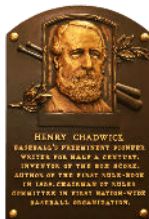
Schwarz (2004). *The Numbers Game*. Thomas Dunne

Phillips (2019). *Scouting and Scoring*. Princeton University Press

Society for American Baseball Research (SABR)

“sabermetrics” (Bill James, **Henry-Chadwick-Preisträger 2010**)

Baseball

[illegible]

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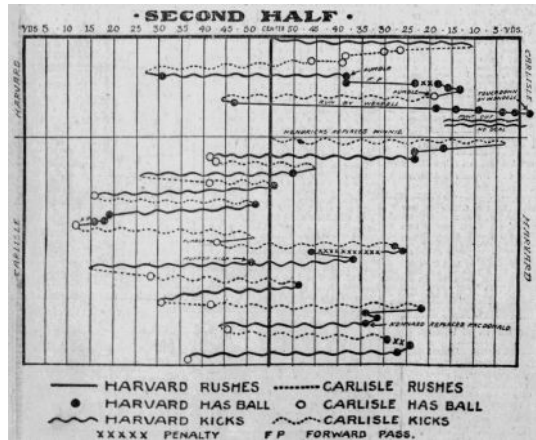
“sabermetrics” (Bill James, Henry-Chadwick-Preisträger 2010)



Bill James Online @billjamesonline · Feb 12

I'm so old, I still get mad when I see a perfectly good space of flat ground being wasted on a soccer field.

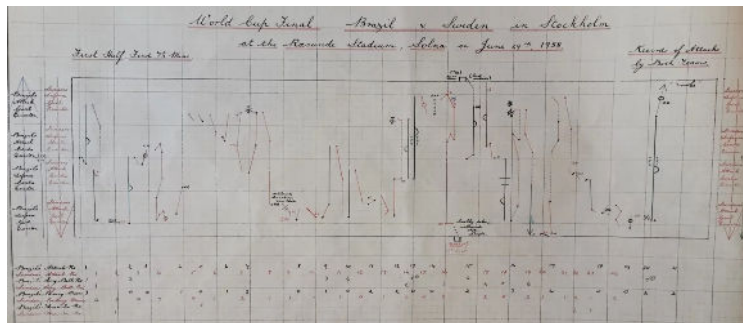
Football



Boston Globe (11. November 1906, p. 2)

Fussball

Charles Reep (1904–2002)



Pollard (2002). Charles Reep (1904–2002): Pioneer of notational and performance analysis in football. *Journal of Sports Sciences* 20(10):853–855



The diagram shows a hand-drawn football pitch with player positions and movement lines. The pitch is divided into three sections: the first 15 minutes of the first half, the second half, and the records of attacks by each team. The diagram is drawn on a grid and includes various annotations and symbols.

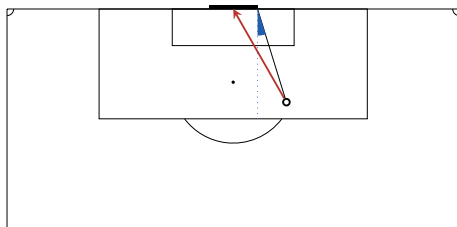
Reep (April 1962)
Are we getting too clever?
World Sports, pp. 22–23

“Je moet schieten, anders kun je niet scoren.” (Crujff)

Pollard & Reep (1997). Measuring the effectiveness of playing strategies at soccer.
Journal of the Royal Statistical Society, Series D 46(4):541–550

erklärende Variablen

- x_1 Abstand von Tormitte
- x_2 Auslenkwinkel
- x_3 mehrere Ballberührungen?
- x_4 Abstand zu Verteidiger?
- x_5 nach Standard?



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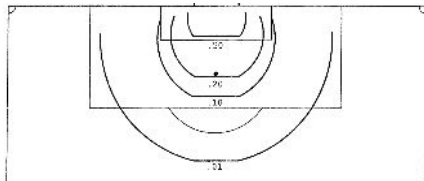
logistische Regression für 22 Spiele der WM 1986 in Mexiko

Torschüsse, unter Druck, freies Spiel

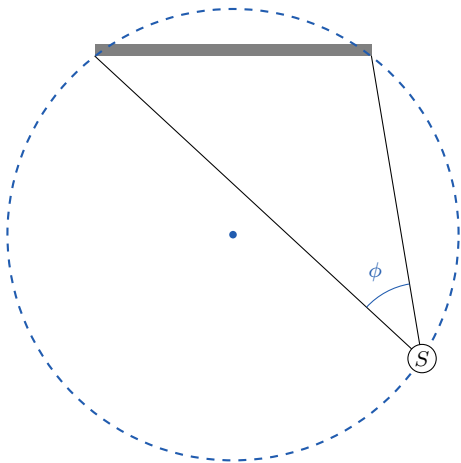
410 Ballbesitzphasen mit Torschuss:

$$p = \frac{1}{1 + e^{-y}} \quad \text{“Torwahrscheinlichkeit”}$$

$$y = -0.219x_1 - 1.578x_2 + 0.947x_4 - 1.069x_5 + 1.245$$

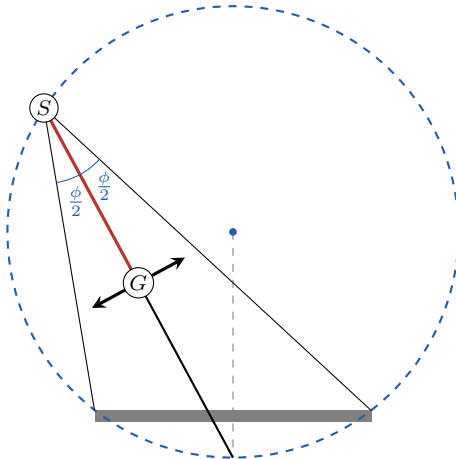


ein anderer Winkel



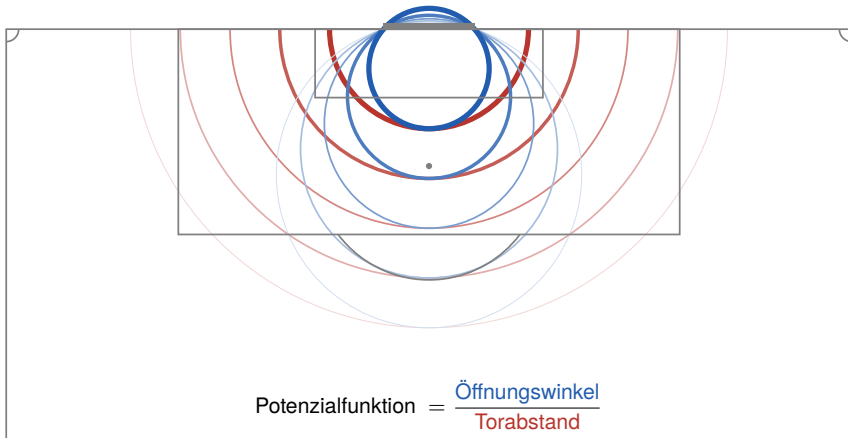
aus einem anderen Winkel

Merkmalsextraktion (in Arbeit)



Bewertung von Abschlusspositionen

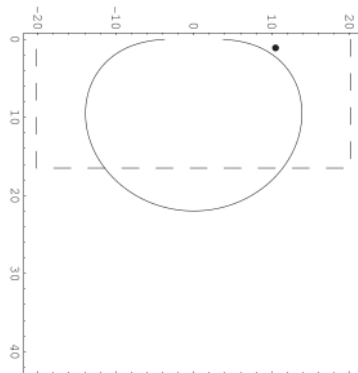
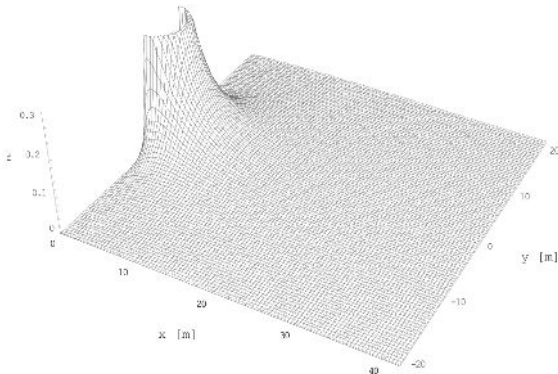
Torgefahr steigt mit Öffnungswinkel, fällt mit Torabstand



Penalty nur bei ausreichender Torgefahr

Morales (2016). A mathematics-based new penalty area in football: tackling diving.

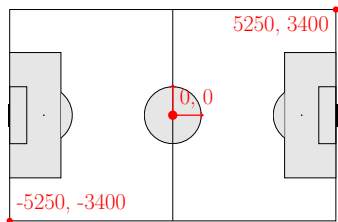
Journal of Sports Sciences 34(24):2233–2237



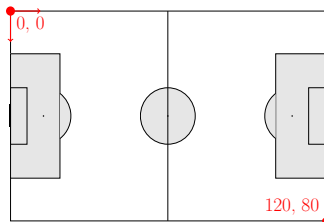
Räumliche Daten

horizontale Ausrichtung, Spielfeld als skalierbares Rechteck

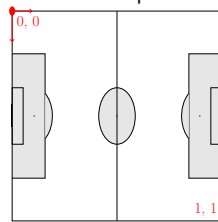
TRACAB



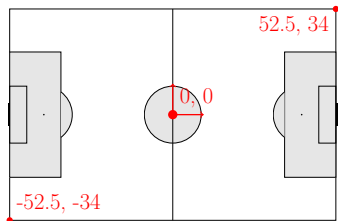
StatsBomb



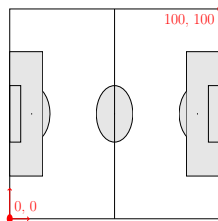
Metrica Sports



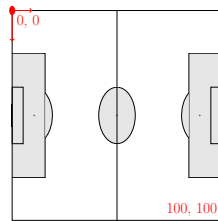
Second Spectrum



Opta



Wyscout



Torbezogenes Koordinatensystem

Publikation in Vorbereitung

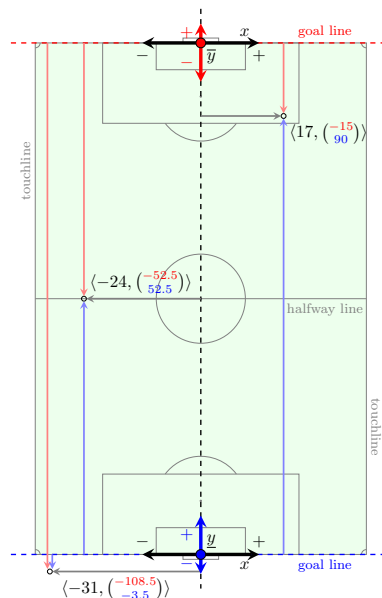
Verzerrungsproblem: Abmessungen variieren, Markierungen nicht

Lösungsvorschlag: Koordinaten $\langle x, \begin{pmatrix} \bar{y} \\ \underline{y} \end{pmatrix} \rangle$ bezüglich Toren, Mannschaftsperspektiven $\Rightarrow$ vier Sichten pro Punkt

GoalCS		Tor	
		Verteidigung	Angriff
Sicht	unsere $\uparrow$	$x, \underline{y}$	$x, \bar{y}$
	deren $\downarrow$	$-x, -\underline{y}$	$-x, -\bar{y}$

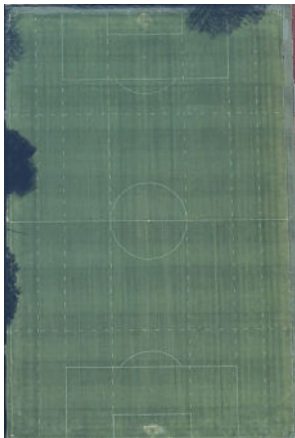
wobei $\underline{y} - \bar{y} = \text{Platzlänge}$

- redundante Koordinaten nur im Computer, nicht in Dateien
- Winkel und Distanzen werden nicht verzerrt
- leichte Zusammenführung über mehrere Spiele

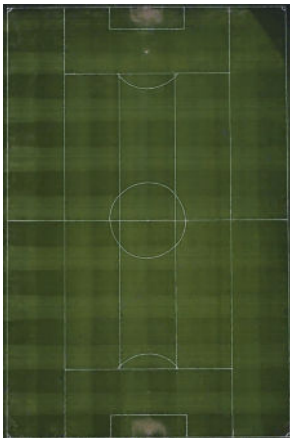


Raumaufteilung: Zonenmarkierungen auf Trainingsplätzen

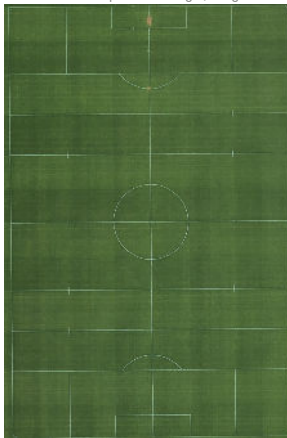
maps data: Google; images © Infoterra Ltd & Bluesky Maxar Technologies



Southampton



Manchester City



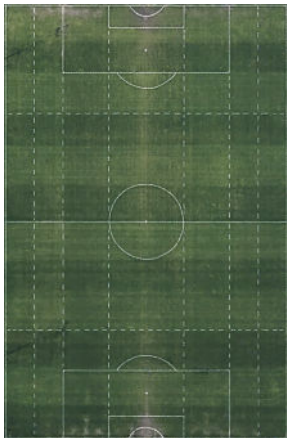
Arsenal



Brighton & Hove

Raumaufteilung: Zonenmarkierungen auf Trainingsplätzen

maps data: Google, © GeoBasis-DE/BKG; images © TerraMetrics



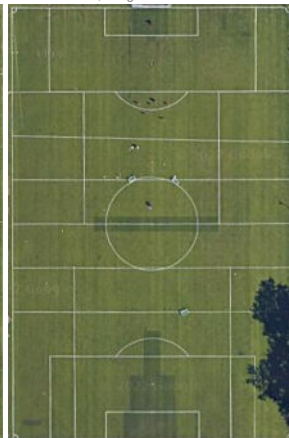
Leipzig



Freiburg



Stuttgart



Basel

Raumaufteilung: Zonenmarkierungen auf Trainingsplätzen

maps data: Google, © GeoBasis-DE/BKG; images © TerraMetrics



Leipzig



Freiburg



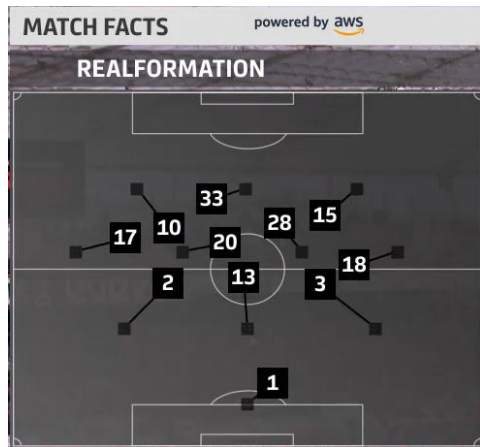
Stuttgart



Basel

Grundordnungen

Bundesliga 2020/2021 bei Sky



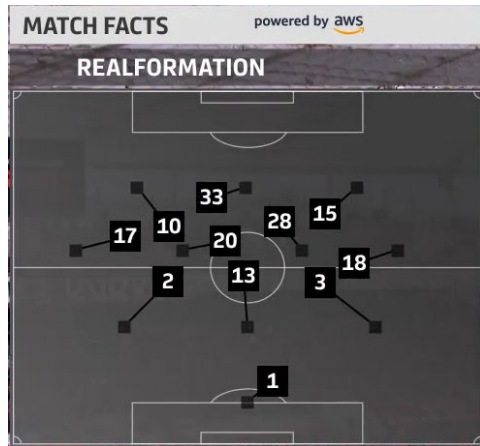
Grundordnungen

Bundesliga 2020/2021 bei Sky



Rolfes (2020):

*Besonders auffällig finde ich dabei, dass die **Realformation** immer deutlich kompakter ist als die ursprüngliche Aufstellung auf dem Papier. Die Abstände zwischen den einzelnen Spielern sind also viel geringer. Oder anders gesagt: Es gibt in Ballnähe meist nur sehr wenige Räume.*

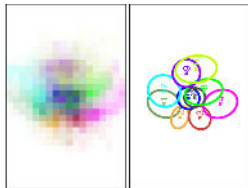


Grundordnungen erkennen

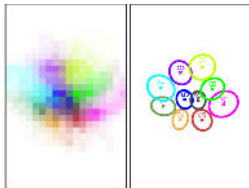
Bialkowski, Lucey, Carr, Matthews, Sridharan & Fookes (2016). Discovering team structures in soccer from spatiotemporal data. *IEEE Transactions on Knowledge and Data Engineering* 28(10):2596–2605

Tracking-Daten (eine Mannschaft, eine Halbzeit, Zentrum jeweils in Platzmitte verschoben)

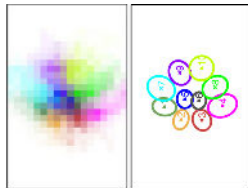
1. Positionen zunächst durch Spieler definiert (ohne Goalie)
2. für jedes Standbild: Neuordnung von Spielern zu Positionen so, dass Distanzsumme minimal
3. Positionen entsprechend Zuordnung aktualisieren, wiederhole von 2.



initial



1. Iteration



2. Iteration

...



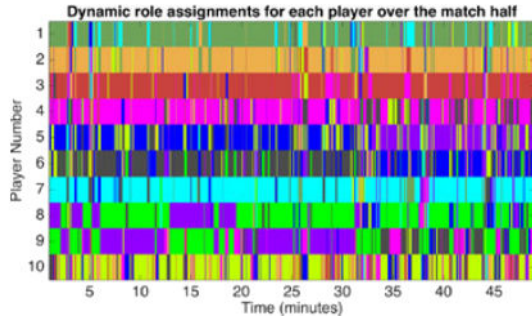
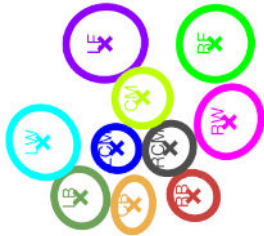
Endzustand

Grundordnungen erkennen

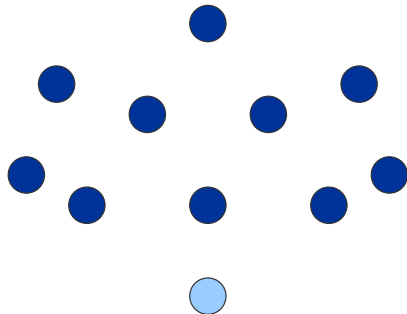
Bialkowski, Lucey, Carr, Matthews, Sridharan & Fookes (2016). Discovering team structures in soccer from spatiotemporal data. *IEEE Transactions on Knowledge and Data Engineering* 28(10):2596–2605

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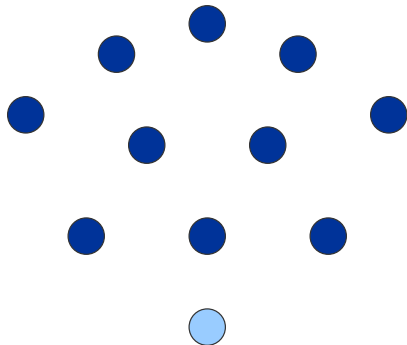
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Zwei Systeme?



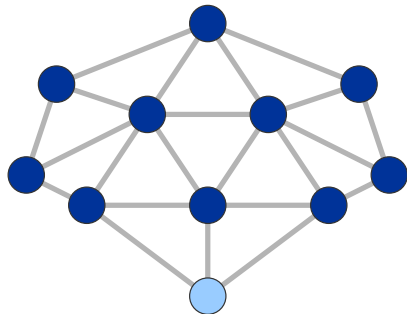
ohne Ball



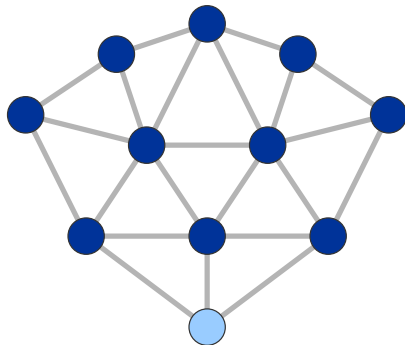
mit Ball

Zwei Systeme? Gleiche räumliche Beziehungen

vergleiche Grundordnungen anhand von Struktur statt Koordinaten



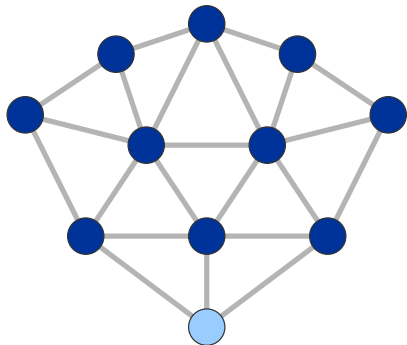
ohne Ball



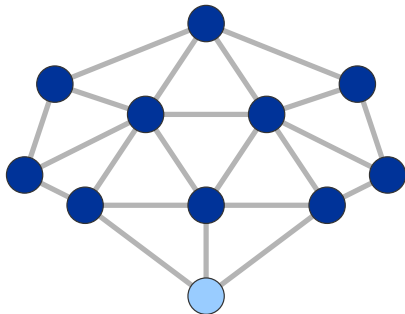
mit Ball

Zwei Systeme? Gleiche räumliche Beziehungen

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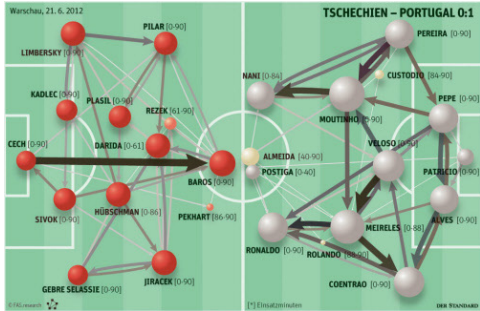
mit Ball



ohne Ball

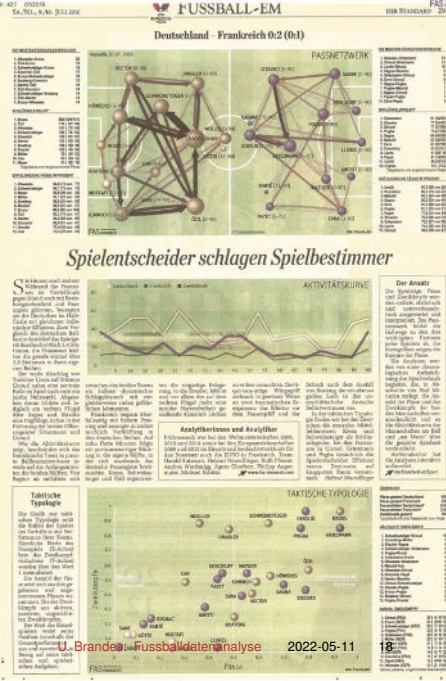
Passnetzwerke interpretieren

z.B. FAS.research in *Der Standard* (seit WM 2006)



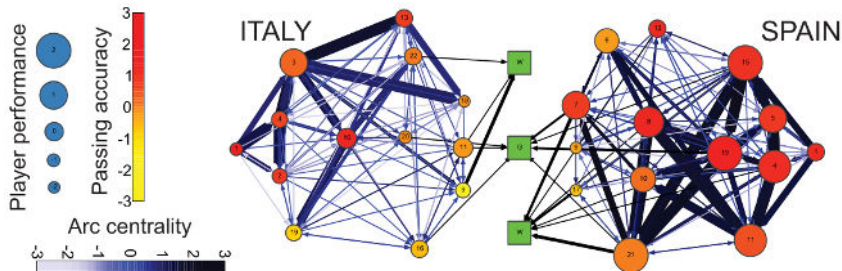
Neundlinger (2012)
Die fadenscheinigen Beziehungen der Tschechen
und die fulminante Regelmäßigkeit der Portugiesen.
Der Standard, Juni 22

Neundlinger (2016). Spielentscheider schlagen Spielbestimmer. *Der Standard*, Juli 8



Zentralität in Passnetzwerken

Duch, Waitzman & Amaral (2010). Quantifying the performance of individual players in a team activity.
PLoS ONE 5(6):e10937

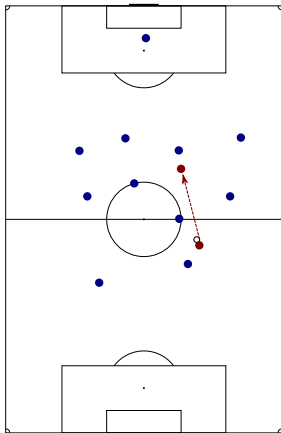


- **Hilfsknoten** für Abschlüsse auf und neben das Tor
- Ballgewinn als Startpunkt für Wege durchs Netzwerk
- **Passquote** und Torabschlussquote als Bewertungen auf Wegen
- “**Durchgangszentralität:**” Vorkommen von Spielern (und Pässen) auf Wegen zu **Torknoten**

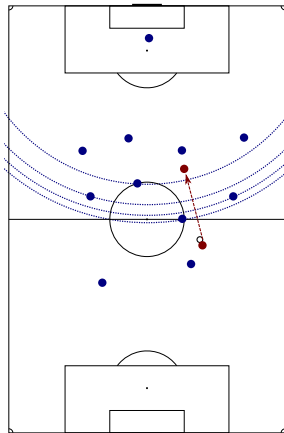
Pässe mit Raumgewinn

in Vorbereitung

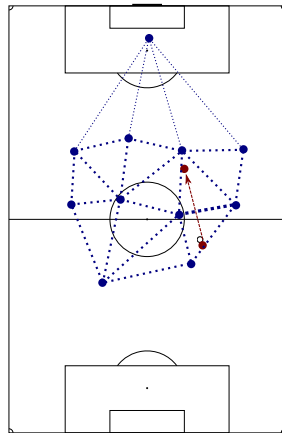
Steilpass



Packing



Schnittstellenpass



Reinartz & Hegeler (IMPECT 2015)

Vorlesung Soccer Analytics

Wissenschaft im Kontext

Mannschaftssport als reguliertes System

- **Messen** vs. *Datafication*
- **Kollektivverhalten**
- unterliegende **Mechanismen**

300+ Studierende

- Informatik
- Mathematik
- Statistik
- Data Science
- Physik
- ...

#	Kapitel	Thema
1	Einführung	Gruppenprojekte
2		Spielregeln
3	Ergebnisse	Rankings & Vorhersagen
4	Individualverhalten	Laufen
5		Passen
6		Schiessen
7	Phasen	Standards
8		<i>Professionelle Gäste</i>
9		Spielzyklus
10	Kollektivverhalten	Grundordnungen
11		Aufstellungen
12	Umwelt	Transfers
13		Fans
14	<i>Final</i>	<i>EURO 2020 Rückblick</i>



Gruppenprojekte



- 51 Teams von 6-8 Studierenden
- Spiele ausgelost
- Spielanalysen
 - Konzepte aus der Vorlesung
 - Wiki
 - Austausch von Code



- Ereignisdaten
- Standbilder
- frei verfügbar



TECHNICAL TOPICS

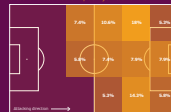
THE CENTRE-FORWARD: TRUE OR FALSE?

THE TRADITIONAL NOY MUST ADAPT TO SURVIVE

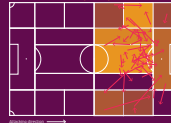
Do these centre-forwards meet extra headchairs for current attacks? The question sparks up more conflicting evidence about the impact of Lewandowski, Kane, Immobile, Lukaku, Berardini, Pionetti, Morisi, Salcedo, Verrini, Matic, Wenderson, Digne, France said: "The fact that we have updated so much about this indicates that, over the whole tournament, a very limited number of centre-forwards have really made an impact." The trend among the modern centre-forwards," Hayes commented, "is that they are often concerned with players with more speed and flexibility. I didn't see many teams playing direct to a target centre, while more attackers are playing in roles that, in days gone by, we called inside-forwards." "Lewandowski is a classic striker," France added, "but Pierre Schick had an excellent tournament. But look what happened to the first when England started playing the long ball. Italy's two strikers dominated every game. They were the ball every time. So what we saw was the type of central attacker who moved wide or went deep."

delivered passes for both goals and changed the match." Morisi and his players admitted that they were made to suffer mightily in the semi-final against Spain. "I think they were surprised, as they expected a rather tight up the pitch," Alar Morisi mentioned. But Luis Enrique finished Dani Ceballos as a false 9. He appeared everywhere and it was very difficult for Italy's players to predict his role. On average, Ceballos offered to move the ball behind the defensive line 2.7 times a game, the second most of any player in the competition. Daniel Ceballos received the ball in the same time, Pedro found a lot of space when Spain were in possession and, as soon as the ball was lost, he picked up Jorginho while Mikel shut down Verrini. Italy couldn't completely test." Statistics confirm that Verrini and Jorginho who jointly delivered 147 passes in the quarter-final against England and 22.8 in the final, dominating possession only 4.6 in the two games against Spain. "For the coach, it is an interesting topic," Kane said. "Maybe most would play a central striker if they had a good one. Ceballos at least played today a lot of problems and Spain controlled the game. But they didn't score until Morisi came on as a striker. That's the player you have to score. If you play a false 9, do you have enough power up front?"

Christian Remonte actions map during the tournament



Dani Ceballos offers to receive against Italy



Fussballdatenanalyse

Ulrik Brandes, ETH Zürich

Bodensee Wirtschaftsforum
Thurgauer Wirtschaftsinstitut
11. Mai 2022

