Sports Visualization

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Introduction

- Lots of **data** collected during sports events
- How to **visualize**?
Example

- **Soccer match**: Austria - Liechtenstein
- Pass statistics of Austrian player (C. Fuchs)

<table>
<thead>
<tr>
<th>Passes</th>
<th>61</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful passes</td>
<td>90%</td>
</tr>
<tr>
<td>Long passes</td>
<td>9</td>
</tr>
<tr>
<td>Short passes</td>
<td>52</td>
</tr>
<tr>
<td>Mainly passed to</td>
<td>M. Arnautovic</td>
</tr>
<tr>
<td>Most passes received from</td>
<td>M. Hinteregger</td>
</tr>
</tbody>
</table>
Soccer match: Austria - Liechtenstein

Pass statistics of Austrian player (C. Fuchs)
Soccer match: Austria - Liechtenstein
Introduction

- Lots of **data** collected during sports events
- How to **visualize**?
- **Sports visualization** techniques to
  - Visually presents data
  - Allows users to analyze data
Introduction

Data Collection

Data Visualization

Sports Visualization

Broadcasting

Sports Medicine
Introduction

Data Collection

Data Visualization

Sports Visualization

Broadcasting

Sports Medicine
Data collected in Sports
Sports Data

- Different **data parameters** collected according to type of sports
- Data can be viewed at **multiple levels**
  - Overview (e.g., team structures)
  - Details (e.g., athletes’ performance)
- Developments over **time**
- Encodes **spatial** positions
- Collects **abstract** data (e.g., passes)
- Data collections can be **large** (“Big Data”)
Sports Data - Examples

- **American football** (per team)
  - Total yards
  - Offensive yards
  - Rushing yards
  - Passing
  - Field Goals
  - Touchdowns
  - ...

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Sports Data - Examples

- **Tennis** (per player)
  - Errors
  - Unforced errors
  - Maximum speed of service
  - Aces
  - …
Data Collection

- **Video** analysis (e.g., team sports)
- **Multi-camera** setups (e.g., Hawk Eye)
- **Manual** data collection
- **Sensors** for sports equipment / players

[3] [4]
Summary

- Data sets are **large**
  - Data collected for every team, player, …
  - Over several seasons
- Data has several different attributes (*time*, *abstract* data, *spatial* data)
- Data collection is **expensive**
- Analysis of the data in sports is becoming more and more **important**
Sports Visualization Tasks
Different **user groups** with different interests

- Athletes
- Trainers
- Fans / Media
- Scouts
- Betting companies
- …
Different **user groups** with different interests

- **Athletes**
  - Performance
  - Comparisons
  - Changes over time
- **Trainers**
- **Fans / Media**
- **Analyst / Scouts**
- **Betting companies**
  - ...
Different **user groups** with different interests

- **Athletes**
- **Trainers**
  - Overview
  - Strengths / weaknesses
  - Decision making
- **Fans / Media**
- **Analyst / Scouts**
- **Betting companies**
- ...
User Groups

- Different **user groups** with different interests
  - Athletes
  - Trainers
  - **Fans / Media**
    - Overview
    - Comparisons
    - “Visualization for the masses”
  - Analysist / Scouts
  - Betting companies
  - …
User Groups

- Different **user groups** with different interests
  - Athletes
  - Trainers
  - Fans / Media
  - Analysts / Scouts
    - Performance analysis
    - Comparisons
  - Betting companies
  - …
Different **user groups** with different interests

- Athletes
- Trainers
- Fans / Media
- Scouts

**Betting companies**
- Accurate data
- Predictions
- Analysis in real-time

…
Tasks

Sports visualization tasks
- Overview+Detail
- Comparisons
- Spatial information
- Changes over time (e.g., trends, outliers)
- Decision making
- “Visualization for the masses”
Sports Visualization Applications
Sports Visualization

- Sports visualization a relatively new field of research
- **Recent** developments in the field
  - According to sports
  - According to used visualization techniques
- **Outlook** for future work
Example - Ice Hockey

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Example - Tournament
Applications can also be categorized according to the used **visualization techniques**

- Heat maps
- Trajectory visualizations
- Graph visualizations
- Arc diagrams
- Glyphs
Overview

Applications can also be categorized according to the used **visualization techniques**

- **Heat maps**
- **Trajectory visualizations**
- **Graph visualizations**
- **Arc diagrams**
- **Glyphs**
Heat Maps

- **2D diagram**, values are visualized by color
- Can be used to display **spatial** information
- Intuitive, good for **overviews**

[8]
Heat Maps for Sports Visualization

- Used to encode **spatial position** of athletes or events

Soccer - Player positions
Heat Maps for Sports Visualization

- Used to encode **spatial position** of athletes or events

Basketball - Shoots

Ice hockey - Goals

[10] [5]
Applications can also be categorized according to the used **visualization techniques**

- Heat maps
- **Trajectory visualizations**
- Graph visualizations
- Arc diagrams
- Glyphs
Trajectory Visualization

- Trajectories are **spatial-temporal** data
- Usually **lines/splines** used to display data
  - Intuitive
  - Additional attributes (e.g., color) to display additional data parameters
Visualize **player trajectories** in team sports

Overview of team **structures** and **moves**

Basketball - Trajectories to analyze team behaviour
Trajectory Visualization for Sports Vis.

- Visualize **player trajectories** in team sports
- Overview of team **structures** and **moves**

Soccer - Visualization of player trajectories
Trajectory Visualization for Sports Vis.

- Visualize **player trajectories** in team sports
- Overview of team **structures** and **moves**

American football - Player and ball movements
Applications can also be categorized according to the used visualization techniques:
- Heat maps
- Trajectory visualizations
- Graph visualizations
- Arc diagrams
- Glyphs
Graph Visualizations

- **Graphs** represented by nodes and edges
- Can be visualized in **2D** or in **3D**
- **Nodes** often visualized as circles/spheres
- **Edges** often visualized as lines (undirected graph) or arrows (directed graph)
Team structures can be visualized as graphs. Players are nodes, relationships between them (e.g., passes) are edges.
Applications can also be categorized according to the used **visualization techniques**

- Heat maps
- Trajectory visualizations
- Graph visualizations
- **Arc diagrams**
- Glyphs
Arc Diagrams

- Special type of **graph** drawing
- **Vertices** are placed along a line, **edges** are drawn as semicircles
Arc Diagrams for Sports Visualization

- Used to display **events** (start = begin of arc, end = end of arc)

American football - Arc diagram of a match
Applications can also be categorized according to the used visualization techniques:
- Heat maps
- Trajectory visualizations
- Graph visualizations
- Arc diagrams
- Glyphs
- **Markers** that represent data
- Visual attributes of the marker corresponds to attributes of the represented data
Glyphs

**Advantages**
- Can encode several attributes in one marker
- Can be used in 2D as well as in 3D

**Possible problems**
- Can lead to false interpretation of the data if placed very densely
- Not always intuitive, learning phase may be required for user
Glyphs for Sports Visualization

- Used to visualize different data parameters
- Glyphs often use different color and shape

Baseball - Glyphs to mark the pitch/catch positions
Glyphs for Sports Visualization

- Used to visualize different data parameters
- Glyphs often use different color and shape

Tennis - Visualization of a tennis match
Glyphs for Sports Visualization

- Used to visualize different data parameters
- Glyphs often use different color and shape

Rugby - Real-time visualization of events

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Sports visualization tasks
- Overview+Detail
- Comparisons
- Spatial information
- Changes over time (e.g., trends, outliers)
- Decision making
- “Visualization for the masses”
<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview+Detail</td>
<td>Basically all methods provide means for overviews, as well as filters for details</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Many applications use side-by-side comparisons, which is limited to a certain number of elements</td>
</tr>
<tr>
<td>Spatial information</td>
<td>Can be provided by heat maps and/or trajectory visualization</td>
</tr>
<tr>
<td>Changes over time</td>
<td>Similar to comparisons, changes over time can be viewed side-by-side</td>
</tr>
<tr>
<td>Decision making</td>
<td>MatchPad [23] provides support for real-time visualization during a match</td>
</tr>
<tr>
<td>Visualization for the masses</td>
<td>Heat maps and trajectory-based visualizations are easy to understand</td>
</tr>
</tbody>
</table>
Pass Statistics in Soccer Discussion
Pass Statistics in Soccer

- **Soccer match**: Austria - Liechtenstein
Discussion

**Soccer match:** Austria - Liechtenstein

- Size of spheres
- Thickness of arrows
- Visual clutter
- Importance of players not according to playing time
Visual Analytics of Soccer Team Formations
Motivation

- During a match, soccer teams play in different formations (e.g., attack vs. defensive)
- Formations are defined by player positions
- Movement data of the players is available
- Therefore, formations, can be automatically derived from the data [24]
- How is the formation/strategy of a team at a certain time stamp?
Soccer is a **dynamic** game, therefore player trajectories over one match will look like this:
Possible to **filter** trajectories (mean positions of players and variance)

**Overlaps** due to players changing position
Removing Overlaps

- Let player have different **roles** during a match
  - Every player can only have one role in a frame
  - Every role can only be present once

Player with stable position
Player with many different roles [25]
When looking at roles, data does not overlap.
Based on the roles, different team formations can be depicted.

When viewed on a timeline, different moves in a match can be seen (e.g., attack).
Team Formations

- It is also possible to compare formations of one team over several matches

**Team A**: similar strategy for all matches, only slight variations

**Team B**: different strategies for home and away matches

Blue: home  
Red: away
Contributions

- **Advantages:**
  - Automatically extract team formations
  - Comparison of team formations over time, or comparison of different matches

- **Critics:**
  - Use of roles may hide tactic decisions
  - Goalkeeper not considered by the system

- **Future work:**
  - Automatically identify teams by analyzing their movement data
Glyph-based Visualization for Real-Time Analysis
Motivation

- Sports visualizations often summarize data of a sports event, after it took place.
- Trainers need to make decisions on demand.
- They need systems that support decision making in real-time.
- *MatchPad* [23] takes real-time event data from a rugby match and displays data on a timeline, to help coaches get an overview of the entire match.
Several **events** recorded during a rugby match (i.e., several hundreds)

- Drop Kick
- Scrum
- Lineout
- Ruck
- …
System uses different **pictograms** for different events

- Drop Kick
- Scrum
- Lineout
- Ruck
Event Data

- Every event has several attributes
  - Timestamp
  - Position
  - Involved team
  - Involved players
  - Outcome
MatchPad Glyphs

- In *MatchPad*, events are encoded as glyphs.
- Glyphs represent event attributes.

The diagram illustrates the main event glyph, metaphoric pictogram, background color as a team identifier, outcome attribute, player numbers (optional), enumerative or numerical attribute (location may vary), and duration bar.
During a match, glyphs are aligned in a timeline according to their occurrence.
During a match, glyphs are aligned in a **timeline** according to their occurrence.
**MatchPad Interaction**

- **Possible to**
  - Scroll through match events
  - Zoom into parts of the match
  - Select events to see video playback

- **User feedback**
  - Good overview of the match
  - Used it for decision making during match
  - Also useful for debriefing
SportsViz *MatchPad*

https://www.youtube.com/watch?v=JeS69Gv71Vg
**Contributions**

- **Advantages:**
  - Novel glyph design which is both informative and easy to understand
  - Timeline-based view of a rugby match
  - Supports decision making in real-time

- **Critics:**
  - Does not include match statistics

- **Future Work:**
  - Could be applied to other team sports
Outlook
Summary

- **Sports data**
  - Several different challenges (time, spatial data, abstract data, …)
  - Large datasets

- **Sports visualization**
  - Usually domain-specific (type of sports, user groups)
  - Uses several well-known techniques from visualization
  - Many directions for future work
Outlook

- Data analysis in sports a rather new topic
- More and more data going to be available
- No standards for data collection (different companies may produce different data)
- Sports clubs slowly start getting interested in data analysis
  - Want to improve their performance
  - New profession of sports statistician [26]
Outlook

- **Summit** on sports data in March 2015
- Speakers with background in data analytics in **soccer** (Premier League and Dt. Bundesliga)

Getting the data is the easy part, it’s how you transfer that into decision-making.

Sam Erith, Man City head of sports science

- People working in sports mainly need tools for decision making
Appendix 1
Examination Subjects
What to learn for the exam

- **Not necessary** to know all sports visualization applications by heart that were mentioned in the talk.

- Talk was mentioned to give an **overview** with more details on the calculation of soccer **team formations** and **real-time visualization** of rugby.

- **Things to learn for the exam:**
  - How does sports data look like
  - What are the requirements for sports visualization
  - Description of the user groups
  - Which visualization techniques are used currently, and how
  - How are soccer team formations computed
  - What is MatchPad
Appendix 2
References
References

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[26] http://stattrak.amstat.org/2012/08/01/sports-statistician/