MathSport International 2017
Book Of Abstract

SESSION 1-A: Modelling and simulation

Using Player Quality and Injury Profiles to Simulate Results in Australian Football

Karl Jackson

Abstract: Traditionally, prediction algorithms in team sports are focused on the results of single matches. Short-term predictions allow an agnostic approach to team selection to be valid, since gross changes in availability and quality of player personnel are unlikely. When aiming for long-range predictions, both of these potential changes become significant factors. This research aims to use projections of potential injuries (prevalence and severity) and player improvement or decline as a means to allow for more accurate simulations of a full season of matches in the Australian Football League (AFL). Injury distributions will be based on observed injuries to AFL-listed players from seasons 2013-2016. Changes in player quality will be modeled on observed changes of player performance as measured by the official AFL Player Ratings, from seasons 2010-2016. This methodology can then be used to forecast team performance, allowing realistic expectations to be set by professional teams, to assess the impact of an uneven fixture on team expectations, and to assess the importance of individual players to a team's expected number of wins.

A Statistical Investigation of Factors Influencing the Results of One-Day Internationals in Cricket

Chris Frankland and Gordon Hunter

Abstract: The effect of playing "home" or "away" and many other factors, such as batting first or second, winning or losing the toss, have been hypothesised as influencing the outcome of major cricket matches. Anecdotally, it has often been noted that Subcontinental sides (India, Pakistan, Sri Lanka and Bangladesh) tend to perform much better on the Subcontinent than away from it. In 2009, Joshi published an article in the Royal Meteorological Society journal Weather which suggested that the prevailing weather conditions were more important to the results of Ashes test series in Australia than were the relative strengths of the teams.

In this paper, focusing on results of men's One Day International (ODI) matches involving England, we investigate the extent to which a number of factors - including playing home or away (or the continent of the venue), batting or fielding first, winning or losing the toss, and the mean temperature and humidity during the game - influence the outcome of matches. We employ a variety of Statistical

techniques, including ANOVA and both linear (for margin of victory) and logistic (for winning/losing the match) regression models, and conclude that the continent of the venue of the match does appear to be a major factor affecting the result (particularly if the match is played on the Subcontinent), but winning the toss or choosing to bat first or second, do not. The influence of weather conditions during the match, and of the score after each stage (in terms of overs or wickets lost) of each innings are currently under further investigation.

Real time measurement of individual influence in T20 cricket

Ankit Patel, Paul Bracewell and Jason Wells

Abstract: A framework for quantifying the influence of an individual competing in a limited overs game of cricket is outlined. Using ball-by-ball data, a resource model is constructed using an isotonic regression and MCMC Gibbs sampling procedure. As a consequence, the impact of an action relative to the current match state can be evaluated. This comparison of observed outcome to an expected outcome on a ball-by-ball basis enables real time player tracking. The cumulative impact of these batsmen-bowler interactions allows individual influence in a match to be quantified. The developed finalized model is validated through live and static application.

Estimating Margin of Victory in Twenty-20 International Cricket

Muhammad Asif and Ian McHale

Abstract: In this paper we propose a model of the runs remaining to be scored in the second innings of Twenty-20 International (T20I) Cricket. The proposed model takes account of overs left and wickets lost. Our model makes it possible to determine the runs differential of the two competing teams. The runs differential not only gauges the closeness of the game in terms of uncertainty of outcome, but also makes it possible to estimate ratings of the teams. Here we use the model to estimate the largest winning margins in T20I cricket history. Sri Lanka's 172 run victory over Kenya in 2007 appears to be the biggest margin of victory to date.

SESSION 1-B: Prediction

Choosing a playing schedule in professional men's tennis

Graeme Ward and Stephanie Kovalchik

Abstract: Professional tennis players are responsible for selecting the tournaments that make up their season schedule. Players have traditionally chosen their schedule without knowing how it is likely to impact their ranking at the end of the season. Very little work has been conducted in analysing schedule choice of single men's tennis and their influence on rankings. This report identifies some variables that contribute to variation in playing schedules and outcomes, including the number

of tournaments entered in ATP Tour and Challenger Tour events, and distance between events. We also developed a score of schedule congestion and examined its variation across schedules.

Based on the premise that players choose a schedule to maximise their ranking, we used data on match results and weekly rankings for 100 male tennis players from 2014 and 2015 and examined two methods to construct predictive models for change in ranks: linear regression and random forests. The performance of each was checked using cross validation.

The goal of the models are to predict the change in rank of a player given the variable values from their schedule as well as their initial rank. It can be used to give an indication about which schedule might be preferable to a player should he have a list of potential schedules he is considering for the season, as it allows him to compare the predicted changes in ranks and therefore final ranks for each schedule. Applications for the models were conducted using sample schedules and initial ranks to show the models' uses, resulting in significant differences in the predicted final rankings of similar ranked players based on the input schedule. This development of the first quantitative model to determine how schedules might influence rankings is a useful starting point for research on schedule choice in professional tennis.

Predicting soccer match outcome using machine learning algorithms.

Chiara Liti, Veronica Piccialli and Marco Sciandrone

Abstract: The aim of this study is to predict the results of soccer matches of Serie A TIM finished with a draw at the end of the first half using only descriptive match-statistics collected during the first half. The analyzed dataset contains the results of matches finished with a draw at the end of the first half during the second half of season 2014-2015 and the first half of season 2015-2016 of Serie A TIM, thus it contains 166 matches. The initial set of features is composed by 53 attributes representing the most relevant match-statistics collected for each team during the first half. Due to the randomness of data and the existence of complex interacting factors, the prediction of soccer match outcomes translates into a hard three-class classification problem (i.e. the Home Win, the Draw or the Away Win). Indeed, the prediction task is complicated by the limited number of overall available examples and by the even smaller number of instances of the Away win class which makes the dataset unbalanced. We manipulated the data in order to better represent the phenomenon and at the same time reduce the number of features given the small number of instances. We tested different classifiers both neural networks based and SVM based. The default version of all classifiers gave poor results due to the entropy of the dataset. The adoption of suitable feature selection techniques and a preprocessing of the data (aimed to eliminate possible outliers) allowed us to attain promising results compared with those of a reasonable baseline. Summarizing, the preliminary results on a small dataset seem to show that the statistics of the first half may provide useful information for a prediction task. However, a deep and wide investigation on larger dataset (with several hundreds of instances) is necessary, and this is object of current work.

The Application of Hurdle Models to Accurately Model 0-0 Draws in Predictive Models of Football Match Outcomes

Alun Owen

Abstract: Much of the published work relating to statistical models of football match outcomes has focused on determining accurate predictive probabilities of a home win, draw and away win. However, this work also typically reports problems with model calibration with respect to accurately predicting the probabilities of actual score outcomes. For example, the common use of Poisson models for goal scoring often includes a factor to inflate the probability of a 0-0 draw. However, we show that these types of models do not universally under-estimate the probability of a 0-0 draw, and instead often actually over-estimate this probability hence requiring deflation of the predictive probability of a 0-0 draw. In this paper we present an alternative novel approach to modelling 0-0 draws, through the use of Hurdle models. These are in essence two-stage models, where in our context, the occurrence of 0-0 scores is modelled as a Bernoulli variable as a first stage (the "hurdle"), whilst a truncated Poisson distribution is then used to model all other scores as a second stage. Hurdle models are therefore suitable for cases where zero-inflation or zero-deflation is required. We show that the use of hurdle models in this context can provide improved predictive accuracy of 0-0 draws, and consider their use in betting on the 0-0 score outcome. Whilst Hurdle models were first discussed in Mullahy (1986), no published work is evident in relation to their application in the context of football outcomes, and so the work presented here represents a novel application of this type of model.

Mullahy, J. (1986). Specification and testing of some modified count data models. Journal of Econometrics, 33(3), 341-365.

SESSION 2-A: Analysis of Play

Paradox of Crosses in Football (Soccer) - A Game-Theoretic Explanation

Sumit Sarkar

Abstract: Regression run on observations for 98 teams playing in the top tires of club football (soccer) in England, Spain, Germany, France and Italy shows significant negative impact of number of crosses per game on number of non-penalty goals scored per game during the 2015-16 season. A game theoretic model explains why crosses adversely affect goal-scoring. Under specific parametric conditions, there exists only a mixed strategy Nash equilibrium (MSNE). In the MSNE, Attack's probability of playing a cross decreases in their accuracy of crosses, heading accuracy and probability of winning aerial balls. The result is paradoxical because these very efficiency parameters increase Attack's chance of scoring from a cross. Defence's probability of using an offside trap increases if Attack is efficient in these parameters, which forces Attack to use crosses less frequently. In the MSNE, teams with a greater chance of scoring from crosses use crosses less frequently than teams having a smaller chance of scoring from crosses. This explains the negative relation between crosses and goals scored.

Flow Network Motifs Applied to Soccer Passing Data

David Perdomo Meza

Abstract: Network Motifs are important local properties of networks, and have lately drawn increasing attention as promising concepts to unearth structural design characteristics of complex networks. In this document, we push the boundaries of the existing body of literature which has used this theory to study soccer passing networks by attempting to uncover unique team passing network structure, and make a rigorous attempt to formalise a theoretical framework in which to carry out and evaluate these analyses. We contribute to the existing body of knowledge by proposing a framework based on repeatability in which to establish the ideal length of flow motifs with which to study soccer passing networks, and also by considering spatial classifications of flow motifs to achieve greater precision in our claim to discover unique team passing network style.

Red cards: (mis)carriage of justice?

Ruud Koning and Lara van Steen

Abstract: A red card is an irreversible decision in soccer matches. One team is left to play with one man short. Ridder et al (1994) show that the team left to play with 11 players has a higher scoring intensity. In the judicial process that follows a direct red card, the decision is sometimes reversed: no punishment is given to the player. In this paper, we assess determinants of dismissal of a red card, and the consequences of these dismissals. Are lower ranked teams more likely to receive red cards that are dismissed eventually? If dismissals of red cards are not random, this would seem to provide another argument for video refereeing during a soccer match.

SESSION 2-B: Tournaments and Scheduling

The Championship Timetabling Problem - Construction and Justification of Test Cases

Jörn Schönberger

Abstract: We consider a sport league timetabling task from table tennis. The timetables for several leagues (forming the championship) have to be setup simultaneously. So-called inter-league constraints require a coordination of the slot assignment for the meetings belonging to different leagues. In particular, meetings with different teams of a club must be assigned into different slots. These inter-league timetabling constraints represent limited venue capacities and the need to preserve table tennis player substitution opportunities between the different teams of a club. We describe the definition and parameterization of test scenarios with different levels of difficulty. Within a Monte-Carlo-experiment we demonstrate the adequateness of these test instances to serve as test field for the evaluation of championship timetabling algorithms.

Scheduling the Australian Football League

Dries Goossens, Jari Kyngäs, Kimmo Nurmi and Nico Kyngäs

Abstract: The scheduling problem faced by the Australian Football League (AFL) has two main objectives, related to travel distance and breaks. The AFL wishes to balance the travel load between teams from the same state, without exceeding the current total travel distance. Furthermore, the total number of breaks needs to be minimized (if a team plays two home or two away games in two consecutive rounds, it is said to have a break). Achieving these objectives is further complicated by an extensive list of constraints, communicated to us by the league authorities.

The AFL scheduling problem has two interesting and relatively novel features. First, the AFL consists of a single round robin tournament complemented with 5 additional matches for each team, mixed with the round robin matches (as opposed to e.g. play-off competitions). Deciding the opponents and the home advantage for the additional matches is part of the scheduling process. Second, some teams have multiple home venues. In addition, two stadia, Etihad and MCG, host almost half of all the matches. Half of the teams play one or more home matches at these stadia, and some teems need to play a minimum number of away matches at Etihad Stadium. Furthermore, as the AFL is trying to expand the sport throughout the country and even to New Zealand, some of the matches are played in cities that do not have a permanent home team.

As the AFL scheduling problem turns out too demanding to solve in a single model, we have developed a 3-phase approach. In the first phase, opponents and home advantage are decided, the second phase assigns matches to rounds, and the final phase decides on the kick-off times and venues. Each of these phases is tackled with an implementation of the PEAST (Population, Ejection, Annealing, Shuffling, Tabu) heuristic, which has proven its value for several other complex real-life problems. We report on our computational results and compare our schedule with the official schedule for the 2013 season.

What a fairer 24 team UEFA Euro could look like

Julien Guyon

Abstract: In 2016, for the first time, the UEFA European Championship gathered 24 men's national teams. It consisted of a group stage made of 6 groups of 4, followed by a knockout stage starting with the round of 16. We critically examine a number of flaws in the design of the knockout bracket that was used by UEFA: group advantage, lack of win incentive, and arbitrary choices. We suggest two fairer procedures that satisfy the balance and group diversity constraints but eliminate group advantage and lack of win incentive. The suggested procedures apply to any tournament consisting of a round robin stage made of 6 groups of 4, followed by a knockout stage.

SESSION 3-A: Data analysis and fitness

Evaluation of a corporate physical activity program to foster well-being using mixed methods

Denny Meyer, Samuel Muir, Madawa Weerasinghe, David Ho and Olivia Sackett

Abstract: Physical inactivity is associated with obesity and has been linked to cancer, diabetes, heart disease and depression. Resulting sick leave and absenteeism, as well as productivity losses, are estimated to have cost Australian businesses $3.6 billion in 2008. Corporate physical activity programs are one way in which businesses can address this problem. In this study we evaluate the impact of such a program using mixed methods. The program is called the Global Challenge and is owned by a commercial company called Virgin Pulse. Qualitative and quantitative survey data was collected concurrently, with validation provided by baseline and post-program performance measures for physical activity, nutrition, wellbeing and productivity. The large sample size (more than 18000 responses) allowed the use of text minig to provide context for when the program resulted in a recommendation to a friend and what participants would miss most about the program. It also allowed the use of conventional generalized linear models and more modern machine learning methods to identify what other factors, such as demographic characteristics and the program features most used, influenced the success of the program. The results provide an understanding of how and why this program can be successful, isolating the drivers for and detractors from success. Particular strengths of the analysis include the use of a mixed methods design, the triangulation of results using baseline and post-program measures to supplement survey responses, the use of sophisticated text mining (parsing, filtering and clustering) approaches, and the integration of the quantitative and qualitative components of the study using machine learning (decision trees, random forests and gradient boosting) approaches. The results will inform future developments of this and other programs designed to increase physical activity and reduce obesity.

A follow-up study of the issue of i.i.d. points in tennis

Francesco Lisi and Francesco Matteazzi

Abstract: Models and quantitative analyses of tennis scores usually assume that the probabilities for the server to win a point are independent and identically distributed over the match.

This may seem counterintuitive to tennis experts, because it is well known that, in tennis, there are more and less important points. Even if some studies show deviations from the i.i.d. hypothesis, others conclude that this deviation is negligible.

In this paper we reexamine in different ways the issue of testing deviations from the i.i.d. hypothesis. First, we define different conditions, or states, of a match. They include tie-breaks, game-points, break-points, important points and the outcome of the previous point. Then, based on the empirical probabilities of winning a point conditionally to any given state, we test the i.i.d. hypothesis by means of both parametric and non parametric approaches.

In particular, we consider parametric and nonparametric independence tests, a logistic model for

the probability of winning a point and some Monte Carlo tests based on simulations.

The analyses are conducted first for specific couples of players, chosen to represent different ranking levels, and, then, considering all players together. We also distinguish between male and female players.

With few exceptions, results tend to confirm the i.i.d. hypothesis.

Determination of sport results based on special fitness of pole vaulters ages 12 and 17

Mariusz Klimczyk

Abstract: Purpose of the study. Indication of the most accurate diagnostic factors of special fitness of athletes training pole vault aged 12 and prognostics for athletes aged 17. Methods of studies. Experimental studies conducted in 2001-2010 involved twenty-two athletes aged 12 and eleven athletes aged 17. Athletes participated in sports activities, training pole vault in the following clubs: Gwardia Piła, Gdańsk Pole Vault Center, TS Olimpia Poznań, SL WKS Zawisza Bydgoszcz, and Śląsk Wrocław. The studies included the method of teacher's observation. Tools applied in the studies included assessment of physical fitness and sport results, conducted during the athletic season. Basic statistical methods were used for the analysis of study results. Results. The author determined interrelation of individual special fitness tests in 12- and 17-year-old athletes and correlation of these tests with pole vault results in the studied age category. It was indicated that in age category 12, diagnostic tests are performed, in which correlation with sport result ranges between -0.45 (15-meter run) to 0.71 (standing long jump). Their purpose is to determine basic parameters justifying continuation of pole vault athletic training. Summary. 17-year-old pole vaulters undergo prognostic tests, which correlation with sport results ranges between 0.64 (shot put 4 kg thrown back over the head) and 0.94 (flying over the bar from a backward roll); their purpose is to predict development of an athlete within training, and ultimately - sport results.

SESSION 3-B: Performance and data analysis

The Nappy Factor in Golf: The Effect of Children upon the Sporting Performance of Professional Golfers

Tony Syme

Abstract: This study investigates the effects of children upon the sporting performance of fathers who are professional golfers. Biographical and sporting data for 225 professional golfers are used to estimate fixed-effects regressions. In line with other studies, it is found that performance and earnings improve significantly after the birth of the first child and that this declines after each subsequent child. The fatherhood premium, or 'nappy factor', is estimated to be an increase in earnings of 10% for any first child, but this rises to 16% if the first-born child is a son and remains the only child. This study suggests that the rank-order nature of tournaments and the non-linear distribution of prize

money within professional golf creates positive incentives to increase work effort, but that tournaments also increase pressure, particularly towards the end of tournament, and that ability to perform under pressure is increased if the player has a son as a first-born child

The effect of leadership on AFL team performance

Kelly Marshall

Abstract: There has been a great deal of evidence for the importance of leaders to a team's functioning, across a wide range of domains including sport. In Australian rules football, 2016 saw a number of high profile team leaders missing a substantial proportion of the season due to injury. For example Carlton's captain Marc Murphy, Gold Coast's captain Gary Ablett Jr, and Fremantle's leadership group member Nat Fyfe all missed a large number of matches. These three teams went on to have a poor overall season performance. In this exploratory paper I will investigate the impact the absence of these leaders had on their team's poor performance, by using a variety of techniques to examine their effect on other team members.

Performance evaluation of volleyball serve using dynamical models of flight trajectory

Maria Angonese, Franco Cardin and Paolo Ferrandi

Abstract: MOViDA is a software platform focused on analyzing and optimizing movements by extracting data, trajectories and other measures automatically. The main goal is to evaluate the performance objectively, by assigning an index to each gesture and monitoring the consistency of the movement. Studying volleyball serves, restricting to ball flight trajectories, the observed data are the starting and ending point of the trajectory, the height of the ball over the net, the velocity during the flight and others. Three different aerodynamic models for the trajectory simulation are considered: the ball is idealized as spherical in the simplest one, while it has prolate ellipsoidal shape in the other two. The models simulate float serves, but also overhand serves in which the ball has an arbitrary spin direction. The most elaborate model takes into account the viscoelastic deformation that the ball may undergo, due to its compressibility, after the impact with the server's hand. After some considerations on the models' sensitivity analysis, MOViDA technology is presented and it is highlighted its potential to support the athlete performance improvement.

SESSION 4-A: Performance and data analysis

Value added as a measure for analyzing batting performance in ODI cricket

Uday Damodaran, Suma Damodaran and Ritwick Chowdhuri

Abstract: In this paper, we analyze the performance of batsmen in One Day International (ODI) cricket adapting a measure that is used in corporate finance to evaluate business performance. In business economics and corporate finance, the super normal economic profits a firm earns during a period -normally a year- is often termed as value added and measured as (Achieved Rate of Return on Capital Employed Minus Desired Rate of Return on Capital Employed) multiplied by the scale of Capital Employed. The term inside the bracket measures the performance above the expected par performance in relative terms; this is then multiplied by a measure of scale to convert the over-performance to absolute terms.

Extending this idea to evaluate the value added by batsmen in ODI cricket we define value added-for each innings played by the batsman- as (Batting Strike Rate for the Innings Minus Par Strike Rate) multiplied by the Number of Balls Faced. The term inside the bracket assesses a key aspect of ODI cricket, the rate at which the batsman is scoring runs; this is then multiplied by the number of balls faced to measure how long he can sustain the scoring rate.

We use the data for all players for all ODI matches played by all countries to demonstrate the method. The critical parameter in the measure is the choice of the par rate. We experiment with various alternatives to arrive at a meaningful definition of par rate that incorporates the game context and player style. We then use the time series data of innings-wise value added for selected players to test for persistence/ mean reversion of super-normal or sub-normal performance

On the stochastic nature of indices of competitive balance

Dimitris Karlis, Ioannis Ntzoufras and Vasileios Manasis

Abstract: Competitive balance is becoming an important issue in the sport research agenda since it is related to several aspects of the sports, including problems related to financing and economic development and success of the leagues. While the literature contains a lot of attempts to define, estimate and work with certain indices, little is known on their stochastic behavior. Calculation of such indices include random errors due the random nature of sports and thus it is important to examine the behavior of certain indices of competitive balance with respect randomness. We adopt a model based Monte Carlo approach to examine the impact of randomness for such indices and thus to correct for the part that observed values can be attributed to randomness or they reflect something more systematic. Examples with European Leagues are provided. A discussion related to the interpretation of such indices in practice is also given.

Which one has more influence in female air pistol performance: experience or training?

Daniel Mon and Arturo Díaz

Abstract: Many factors affect shooting performance. There seem to be a consensus in which the experience and the training time determine the performance in shooting sport[1]. Unfortunately is not completely clear which one is more important, experience or training, especially in women. The objective of this study is to analyse the training and experience influence on the Olympic female air pistol performance.

Methods: 23 female shooters who participated in a Spanish air pistol championship filled a questionnaire about her shooting experience in years and how much they trained every week in hours per week before the competition. The data obtained were correlated with the official competition performance.

Results: Significant correlations were found between the participants' training and the performance $R2 = 0.17$. The linear regression equation predicting performance was the following: Performance $= 9.37 + 0.04 * \text{Experience} - 0.006 * \text{Body sway}$, $R2 = 0.79$.

Discussion: As previous studies have showed, both training time and shooting experience determine performance. Our data are in concordance with the previous studies [1]. The training time seems to have a more direct influence in the performance than in the experience. On the other hand, experience seems to affect performance when is combined with the body balance.[2]

[1]. Gulbinskienė, V. and A. Skarbalius, Peculiarities of investigated characteristics of lithuanian pistol and rifle shooters' training and sport performance. Ugdymas Kuno Kultura, 2009: p. 21.

[2]. Mon, D., Estudio de las variables de equilibrio, fuerza y antropometría determinantes del rendimiento en tiro olímpico en la modalidad de pistola aire., in Deportes2016, Universidad Politécnica: Madrid. p. 195.

SESSION 4-B: Strategy

Strategy optimization in beachvolleyball – applying a two scale approach to the olympic games

Susanne Hoffmeister and Jörg Rambau

Abstract: Our two scale approach uses two connected Markov Decision Problems (MDPs) to give strategy recommendations for the olympic final in beachvolleyball. The approach relies only on the individual player skills that are estimated from analyzing video records of the pre final matches. In the more detailed MDP, called gameplay MDP, these skills are used to simulate the outcome of serves and field attacks for a certain pairing of teams. Nearly every thinkable team strategy can be implemented and simulated. After knowing the probability for a direct point and fault after a serve or field attack, it is possible to determine the strategy with the highest winning probability. For this purpose a second, more aggregated MDP is used. When using perfect knowlegde about the final match, that means,

we use a strategy that is similar to the strategy in the final match and skills estimated from the final match, we can estimate the outcome of serves and field attacks with an average absolute error of three percentage points. Furthermore, we derived analytical bounds for the simulated probabilities in terms of the individual player skills. They are evaluated and compared with the simulation results of the men's olympic final. In order to give an overview of the optimal strategy for varying opponents performance and the own form on the day, we invented skill-strategy-score cards. They tell at a glance how sensitive the optimal strategy is.

Optimizing a Golfer's strategy with MDPs

Matthieu Guillot and Gautier Stauffer

Abstract: The goal of a golfer is to put a ball in a hole in a minimum number of shots. Each time the golfer hits the ball, he has to decide upon which club to play (among a finite set of 14 clubs) and which target to aim at. As the player does not always play perfectly, the ball does not necessarily ends exactly where it was expected. Weather conditions and obstacles on the field (trees, etc...) can also disturb the theoretical trajectory of the ball. The golfer is facing a decision problem which can be modelled naturally as a special type of total cost undiscounted Markov Decision Process, called the stochastic shortest path problem. This is a natural extension of the deterministic shortest path problem whereby traversing an 'arc' may now lead to several destinations with different probabilities. In this setting, vertices are called states and arcs are called actions. The goal is to decide in each time step and each state which action to take in order to converge to a predefined target with probability one over an infinite time horizon. Taking an action has a cost and we wish to find a policy that minimizes the average cost over all possible realizations. In the golfer's problem, the states are the different (discretized) positions on the golf course and the actions are the different (discretized) choices the golfer can make. Once an action is performed, the probabilities to end up in the different states can be evaluated with respect to the golfer's skills and other external conditions (weather conditions, obstacles. Each action accounts for one shot (or two in particular cases) and the goal is to minimize the expected number of shots until the player hole the ball. We solve exactly the problem using different classic methods from the litterature and some methods we developped, and we compare the computational performances. Moreover, we also report upon some tests we ran with real data from elite French golfers. This is a joint work with Fédération Française de Golf.

Real time forecast of volleyball offensive strategy using machine learning techniques.

Daniele Arosio, Paolo G. Ferrandi and Pietro Mariani

Abstract: To increase the chances of success in volleyball matches a correct evaluation of the opponents strategy is fundamental. The key role in the offensive strategy is performed by the setter: at every action he has to choose the attacker with the best probability to win the point. To reach this aim, he takes into account the importance of surprising the opposing defense.

In order to set up an efficient defensive strategy two aspects are essential: to study the opponents

game tactics and to interpret immediately how the strategy is changing during the match. At this purpose and in partnership with the Italian national volleyball team, a decision support system that predicts the choices of the setter in real time, depending on game situations, has been developed.

Firstly data are collected by "scoutmen" during the matches. Secondly, many predictive models of setter's behavior based on previous games are generated, using machine learning algorithms on a training dataset. These models take into account different variables that describe a particular game situation, such as lineup, score, rotations, service type and reception type. Then a validation dataset is used to select the models with a better foresight. At last, during the game, these models are combined with suitable weights to be adapted to setter strategy in real time. Using this approach, the tool forecasts the setter behavior with respect to the next action.

SESSION 5-A: Modelling and simulation

Estimating the Duration of Professional Tennis Matches with Varying Formats

Stephanie Kovalchik and Martin Ingram

Abstract: There is growing concern in professional tennis over the duration of tennis matches. Yet as governing bodies begin to consider introducing faster match formats like Fast4, the impact these formats could have on the professional game remains poorly understood. In this paper, we develop a shot-level Monte Carlo match simulation approach for estimating the duration, points played, and upset probability given a specific match format. Our model is built on studies of predictors of the in-play and between-play time of matches using Hawk-eye tracking data and publicly available shot-level tennis data. When we applied our models to a variety of match formats with serve characteristics that were representative of current elite players, we found that Fast4 formats had an expected duration of 1 hour, best of 3 of 90 minutes, and best of 5 of two hours. Our results also show that longer matches tend to favor the better player and make match outcomes more predictable. Fast4 formats have a typical upset frequency of 20% compared to 13% for best of 3 matches and 10% for best of 5 matches. The modeling approach we have developed can be a useful resource for tennis governing bodies in assessing the impact of new match formats.

Formula 1 lap time modeling using generalized additive models

Paolo Vidoni and Claudio Casella

Abstract: In this work we define a fairly simple statistical model with the aim of describing team and driver performances using Formula 1 data with regard to season 2015. The estimated model may be considered also for evaluating and simulating alternative race strategies. It is well-known that the modeling of Formula 1 races is an extremely complicated task, since car and driver performances depend on a number of explicative variables, which usually interact, and on the occurrence of unpredictable events such as safety car or virtual safety car, driver's error, breakdown or car crash. The

logarithmic transformation of the lap times are modeled as a function of each lap of the race, taking into account also qualifying position, first lap, tyre degradation, type and age of the tyres, fuel consumption, team and driver, traffic and interactions between drivers, pit stop and first lap after pit stop, occurrence of the safety car. We consider a suitable generalized additive model where the linear predictor involves a sum of smooth functions of the covariates. This model permits a rather flexible specification of the dependence of the response on the numeric and the factor predictor variables. We fit the model using the data obtained from the Ergast Developer API (www.ergast.com/mrd), which is an experimental web service providing motor racing data, and from the Pirelli web page (www.pirelli.com). In particular for a grand prix without events such as safety car, virtual safety car or race suspension, the fitted model can be fruitfully considered for understanding the alternative, observed or potential, race strategies, with particular regard to the pit stop choices.

A Markovian approach to Darts

Luca Parolini, Francesco Bortolon, Lorenzo Schiavon and Cristian Castiglione

Abstract: The aim of this paper is to study and simulate a classical Darts-501 match using Markov chains to describe score evolution. The Markovian approach, indeed, fits the problem since the probability of obtaining a certain score at each step depends only on the result of the last throw and on the score at the previous step. We first study the single dart throw, in order to determine the probability distribution on the dartboard and calculate the probability of hitting each score region, fixed an aiming point; these preliminary results have already been studied in other works. Then, we determine the best strategy the player would choose at each step and we construct the transition matrix of the Markovian process describing the score. We simulate the whole match obtaining results about the average number of steps needed to win it and about the chosen strategies at each step, that both depend on player skill. It is interesting to observe the influence the variance on the player throws has on these data.

How long does a tennis game last?

Marco Ferrante, Giovanni Fonseca and Silvia Pontarollo

Abstract: Tennis is a sport that can be nicely described with a simple mathematical model. Assuming that the probability that a player wins one point is independent of the previous points and constant during the match, the score of a single game, of a single set and of the whole match can be easily described by a set of discrete or continuous time, homogeneous Markov chains. A complete account on this approach can already be found in the literature.

We present a generalisation of previously considered Markovian models for Tennis that overcome the assumption that the points played are independent and identically distributed. Indeed, we postulate that in any game there are two different situations: the first 6 points and the, possible, additional points after the first deuce, with different winning probabilities. Under this assumption, we are able to compute the winning probabilities of a game and a set. Moreover, we assume that the duration of any point is distributed with an exponential random time. We are able to compute the law of the (random) duration of a game in this more general setting.

SESSION 5-B: Rules and Fairness

What Performance Data Tells Us about PEDs in Olympic Athletics and Swimming

Ray Stefani

Abstract: A statistical analog to the chemical passport is used to identify possible uses of performance enhancing drugs among Olympic champions in athletics and swimming and to identify the affect of anti-doping efforts. During the 28 years from 1960-1988, athletics Olympic champions improved 21% in throwing events, 12% in jumping events and 5% in running events. After 28 years under increased anti-doping introduced in 1988 and with the chemical passport introduced in 2008, Olympic throwing champions are 2% worse while jumping and running performances are about the same. Female champions improved 14% from 1960-1988, compared to 7% for men. From 1988-2016, women were 1.4% worse while men were about the same. The winners were so juiced with PEDs in 1988 that after an entire generation under anti-doping, champions in athletics are slight worse than in 1988. In swimming, the 1972 and 1976 winners showed usually large percent improvements, coincident with the introduction of goggles (dramatically increasing training time) and new events. Complaints of PED use by East German women appears justified in that male and female champions had improved the same from 1960-1972; but female champions, mostly from East Germany, improved 1.5% more than men in 1976. As of 1988 when East Germany last competed, the gender gap grew to 1.8%. However, from 1988-2016, male and female champions each improved 4%. In 1996 after anti-drug efforts began in swimming, for the first time in Olympic history, swimming champions were worse than four years before. Janet Evans complained that Ireland's Michelle Smith must have been taking PEDs, after Smith improved and won three gold medals with mediocre times. The fact that an elite swimmer assumed that performances ought to be worse in 1996 indicates that elite swimmers probably had ceased taking some form of PED. The fact that only one medal in swimming has been stripped compared to 31 in athletics may belie subtle PED use in swimming, as Mark Spitz hinted.

On Reducing Sequence Effects in Competitions

Yigal Gerchak and Eugene Khmelnitsky

Abstract: Many sports include a phase where the teams or the athletes take turns performing a task and the winner is the one who has the most successes. Examples include penalty shots when a soccer game results in a tie and a winner has to be declared, playoff series in various sports where a "turn" is a home game, as well as the manner of playing the overtime in a tied American Football game. The sequence in which the attempts are played in many of these tie-breakers has a real or perceived effect on the outcome. The common way to determine the order or sequence in such situations is by coin-toss. However, while this constitutes "ex-ante fairness", it does not generate "ex-post fairness" and it is considered rather undesirable to allow a coin-toss to affect significantly the outcome of a match. In tied soccer games that require a clear winner, teams typically take turns shooting a total of 5 penalty shots each from a distance of 11 m.: ABABABABAB. Many fans and sports reporters believe team A

to have a "psychological advantage" in this shoot-out and there is some empirical research supporting that (Palacio-Huerta et al., 2010). Other empirical research, however, refutes those findings (Kocher et al., 2012). Similar tie breakers are now used in the NHL. An interesting idea is bidding for the place in the sequence by the difficulty of the task. For example, in the NFL overtimes a situation may arise whereby if team A bids "75 yard line" (i.e. to start from its own 25 yard line) and team B bids "70 yard line", team A would start on offence from (75+70)/2=72.5 yard away from team B's end zone. A kickoff spot may be adjusted accordingly. In soccer, assuming that each team is allowed only one kick, the bid could be for the distance of its kicking point from the goal. If A bids 28 m. and B 23 m. then A would kick first, from a distance of 28 m. , while B would kick second from either 11 m. ("Rule 1") or from 23 m. ("Rule 2").

Manager's capacity and limit on foreign players: what influences variation of players in the field?

Ksenia Andreeva

Abstract: Limit on foreign players is a common instrument to promote national players in different sports, including football. It is usually imposed in several forms, such as limit of players in an application for a season (Portugal, Turkey, Austria), limit of players in the field (Ukraine, South Korea), stronger requirements for foreigners (England), restrictions on import from a particular country (Spain, Finland), restrictions on transfer turnover (Italy), limit of young players (Netherlands, Norway, Denmark), etc. Sometimes even economic barriers may refer to regulative policy (the lower wage level is, the less attractive a league becomes for foreign mature players).

The core issue about the limit are uncertain consequences of its implementation. Statistics show that a percentage of foreigners in countries with strong limit may be more or less the same as in countries without special limit (compare France or Netherland with Russia). Moreover, the Russian case of the limit on foreign players has revealed the following results: no evident for better foreign players' characteristics, no increase in game time of national team members, not much more investments in young players, no influence on competitiveness of the Russian national team in international tournaments. However, one of the major results of the limit is wage rise, both for Russian and foreign players.

Generally, it is quite common to analyze influence of some variables on team performance through econometric models. The purpose of my research is to evaluate the effect of the limit on the intermediate indicators, such as number of combinations available to team's manager when making decisions on particular players on the field. For example, I've already proved that switches from the "seasonal" limit to the "field" limit decreases rotation capacity for coaches.

Practical results of this research may be used in making decision process on regulation mechanisms of the labor market in developing countries.

SESSION 6-A: Analysis of play and scheduling

Sensor Analytics in Basketball

Marica Manisera, Rodolfo Metulini and Paola Zuccolotto

Abstract: Global Positioning System (GPS) devices capture the location on space of entities repeatedly over time, generating spatio-temporal data. These devices are nowadays intensively used in team sports to capture the trajectories of players and /or the ball -sometimes together with play-by-play recording the time of match events - with the aim of infer useful informations to coaches in addition to traditional statistics.

In our application to basketball, we collected sensor data related to the location of players during all the official matches played by a team militant in the "C-Gold" league in Italy. Data reports x-axis (width), y-axis (length) and z-axis (height) coordinates for a time series recorded at millisecond level. The play-by-play reports relevant events (such as made shots, fouls, etc ...) together with their moment in time.

The aim of this study is to find any regularities and synchronization in basketball players movements, with the final objective of extracting insights on the relations between particular spatial patterns and the performance of the team. By means of different statistical techniques, such as Cluster Analysis, MultiDimensional Scaling (MDS) and Principal Components Analysis (PCA) we split the match in a number of groups, each identifying homogeneous spatial relations among players in the field.

These methods permit to characterize groups in terms of some relevant properties, such as differences in spacings among players, whether each group corresponds to defensive or offensive actions, or in terms of the transition probability from a certain group to another one. Results of this kind of analysis are the starting point for identifying a possible relationship between the identified patterns -in terms of players' spatial relations- and the team's performance -in terms of field goals percentage or other relevant match events.

Optimal Shot Selection Strategies for the NBA

John O'Brien and Mark Fichman

Abstract: "The NBA's most efficient offense seek out layups and threes." (Ben Cohen, The Basketball Team That Never Takes a Bad Shot, WSJ, January, 2017).

In a risk/expected payoff setting is this an optimal mixed equilibrium strategy? We conduct this analysis using 2015-16 NBA series, notable for the Warriors record-breaking season coupled with the dramatic final series upset by the Cavaliers. We divide the court into eleven different zones and compute both offensive and defensive shot distributions (i.e., points generated/given up) for each zone by team, from regular season games. We derive the log-optimal constant mixed strategy equilibrium for each pair of teams from their shot distributions. We solve for the mixed strategy equilibrium by employing the Markowitz portfolio method combined with a numerical mean-variance approximation to the log utility problem. From these results, we are able to derive the optimal mixture of 2 point and 3 point shots to be taken from different parts of the basketball court over the course of a game. Our results are strikingly similar to the strategy described in the Wall Street Journal article referred to

above. The practical advantage of this approach is that it provides a rich set of insights into NBA basketball strategy. First, we can rank each team's regular season performance relative to the log-optimal strategy and the Warriors had the highest ranking. Second, the results highlight the important role of defense. The solution from the joint offensive/defensive distribution problem results in a higher proportion of 2-point shots compared to the optimal mix of 2- and 3-point shots when ignoring defensive distributions. In other words, what stops the game from degenerating into mainly 3-point shots is strong defense, which counterbalances the additional payoff advantage from scoring 3-points. In addition, this analysis indicates how to re-balance across zones when playing against stronger/weaker defenses.

The Social Doubles Tournament Problem

Fabio Salassa and Federico Della Croce

Abstract: Sport scheduling problems attract the attention of researchers and practitioners in many scientific research branches such as mathematics, statistics and economics. Sport scheduling problems generally involve 2n teams that have to play against each other once (resp. twice) in single (resp. double) round robin tournaments. In the present work, we introduce a novel recreational sport scheduling problem: the Social Doubles Tournament Problem (SDTP). SDTP relates to teams composed by two players as in tennis doubles matches. It consists in creating a tournament of players where teams (composed by pairs of players) are not fixed a priori but have to be generated while creating rounds. SDTP can be defined as follows. Each player has to play with all other players as playmates and against all other players as opponents during a complete league. Also, each player must play both the same number of times i (typically i=1) with all players and the same number of times j=2i against all opponents in a round robin tournament. SDTP can occur when designing amateur competitions for sports like tennis and badminton or for card games like bridge and, more in general, when the schedules are based on non-predetermined couples of players. This problem has its best application with 4k players (as every match is composed by 4 players) since schedules with 4k-1 rounds (that is i=1) can exist. Similarly, instances with 4k+1 players, introducing a bye each round, can induce schedules with 4k+1 rounds. Besides, we show that for instances with $l = 4k+2$ or $l = 4k+3$ players, schedules with a reasonable number of rounds (lower than 3l) do not exist. We propose an ILP of SDTP that allow to compute feasible solutions for different instance sizes. The relationship of a family of SDTPs with specific cardinality with combinatorial design and with the Social Golfer Problem (another well-known sport scheduling problem) is also investigated allowing to derive a feasible solution of SDTP with 28 players.

SESSION 6-B: Betting

Detecting Match-Fixing in Tennis in In-Running Betting Markets

Oliver Hatfield, Jonathan Tawn, Christopher Kirkbride, Timothy Paulden, David Irons and Grace Stirling

Abstract: Match-fixing presents a serious and challenging problem for sport in the 21st century. Tennis has seen particularly widespread coverage of its match-fixing issues in 2016, and it is here that our particular research is concentrated.

Although match-fixing is, by design, difficult to detect, the literature demonstrates that the betting activity of match-fixers may lead to distortions in the betting markets. We would therefore expect the predictions of (sufficiently accurate) sports models to show a larger discrepancy with the odds in fixed matches than they would otherwise. Moreover, while the majority of match-fixing detection in the literature considers pre-match markets, our focus is on detecting match-fixing within an in-running scenario.

A key challenge in assessing the discrepancies between odds data and statistical predictions lies in understanding the uncertainty of both measures. Towards this goal, we extend the widely-used Glicko model to provide estimates of match-win probabilities in tennis with uncertainty, using data from ATP World Tour, Challenger Tour and Futures tournaments from 1991-2016. We then utilise the combinatorial structure of tennis to update our pre-match predictions throughout the match, maintaining uncertainty in a novel manner. Our predictions are compared with live odds data (on a game-by-game level) from 265 men's matches, provided by ATASS Sports, with whom we have collaborated on this project.1 We also explore uncertainty that arises in the generation of odds across different matches. While our early work shows promising results, further work remains to reliably pick up some of the more subtle anomalies.

Bowling Strategy building in limited over cricket Match: An application of Statistics

Akash Adhikari, Rishabh Saraf and Rishikesh Parma

Abstract: The idea involves implementation of statistical operations and data analysis, to deduce a dominance factor, that will facilitate to select the most efficient bowler in a limited overs cricket match. The factor will ultimately simplify strategy building for the corresponding team. The research includes analysis of data of all bowlers in their past matches. The data primarily comprises of two important parameters: Runs conceded and number of deliveries bowled, in between fall of consecutive wickets in a spell of the respective bowler. These parameters are used to calculate a factor (Dominance factor) for all the bowlers of the team under consideration. The Dominance factor will sort the bowlers in terms of priority for a particular over span. This will help the team to decide their bowling strategy. The result can be of great use to bid for bowlers during cricket league auctions, to make an optimum bowling unit for the team. Also, people who frequently play bets can make good use of the dominance factor to decide the bowler to bet on , which will increase their probability to win.

Identification of Multivariate Outliers: A Study for Hockey and Football Data

Blanka Sediva

Abstract: This paper presents the findings of multivariate statistical analysis of the results and of the odds betting on professional hockey and football games. The aim of the analysis is the identification of outliers results in this data. Outliers are observations or measures that are suspicious because they are much smaller or much larger than the vast majority of the observations. The detection of outliers observations can be used as the method for identification of the potentially risk investments for bookmaker.

SESSION 7-A: Ranking

Applying Occam's Razor to the Prediction of the Final NCAA Men's Basketball Poll

John Trono

Abstract: Several approaches have recently been described that attempt to match how the coaches vote in the final poll that is taken after the men's NCAA basketball championship concludes. The new strategy presented here: is more straightforward than prior approaches; has demonstrated reasonably high correspondence with the actual, final polls; and its results can be generated much more easily than the most accurate of the aforementioned approaches.

A comparison of the Performance of Google PageRank to other Ranking Systems on the NCAA Basketball Tournament

Anne Pilkington and Paul Coletti

Abstract: We compare the performance of Google's PageRank ranking system on predicting outcomes in the NCAA Basketball playoffs over the years 2010 to 2016 to other popular ranking systems, namely Colley, Massey and Keener. We use both raw and weighted versions of the rankings and as a measure of effectiveness, we use the score for the ESPN challenge, which requires one to complete the bracket before the tournament begins. The scoring system gives ten points for a predicted win in round 1 and doubles the number of points given for a win in consecutive rounds culminating in 320 points for having predicted the winner of the final round. The results show that although the PageRank algorithm outdid the other systems in 2015, it does not show a high degree of consistency. Statistics for the other ranking systems also exhibit a high degree of variability.

An impossibility result for sport rankings

Laszlo Csato

Abstract: Assume some sports teams are given with information about the outcomes of their matches. An axiomatic approach is applied for the problem of ranking the teams. Consistency requires the preservation of two teams' relative ranking if two sets of matches (e.g. those played in the first and second half of the season) are aggregated. Self-consistency assigns the same rank for teams with the same performance, furthermore, a team should be ranked strictly higher if it shows an obviously better performance than another. It is revealed that these two properties, consistency and self-consistency cannot be satisfied simultaneously if there are unplayed matches in the schedule. The impossibility holds under various restrictions on the domain. However, a positive result emerges if only the aggregation of ranking problems with the same comparison structure is allowed, for example, we have two round-robin tournaments.

Ranking ski courses using permutation methods for multivariate populations

Anna Eleonora Carrozzo, Rosa Arboretti and Luigi Salmaso

Abstract: Monitoring perceived performance of sport trainers is usually a difficult task. The Board of Professional Ski Instructors of the Province of Bolzano and the Ski Schools in 'Alto Adige' were interested in investigating the satisfaction of people attending Ski courses in this area.

A specific survey has been planned to investigate different aspects of satisfaction, such as on course organization, on teaching, on fun etc. The aim of the statistical analysis was multi-fold (1) to obtain a ranking of the ski courses from the 'best' to the 'worst', (2) to identify relevant drivers to differentiate ski instructors/schools and (3) to set up a suitable multivariate methodology able to test for multiple outcomes with stratified data.

Usually such an analysis is performed for each domain of satisfaction and they are kept separate. In the present work we provide a procedure to compare the performance of ski courses considering simultaneously all domains of satisfaction/quality and stratifying by covariates e.g. the nationality or the age of the attendees.

This procedure is based on an extension of the Nonparametric Combination (NPC) of dependent permutation tests (Pesarin and Salmaso, 2010) and it allows us to take into account several aspects affecting the ski performances.

SESSION 7-B: Modelling and simulation

Draw importance in football

Michael de Lorenzo, Stella Stylianou, Ian Grundy and Bradley O'Bree

Abstract: Probabilistic models have been frequently applied in professional sports to quantify the importance of winning a match. However, existing models fail to account for the possibility of a draw outcome, a frequent occurrence in multi-result sports like football. In this paper, we calculate match importance using a trinomial distribution model that accounts for the possibility of a drawn result. Using German Bundesliga football, we demonstrate through case studies that the importance of a match can be evaluated with respect to win and draw results separately.

Modelling clubs' financial investment in association football players

Lars Magnus Hvattum and Olav Drivenes Sæbø

Abstract: Soccer clubs' expenditures related to player transfers have increased significantly in recent times, as broadcasting rights are securing a high income and competition is fierce. Few academic studies have attempted to evaluate the soundness of transfers made, in particular from a financial point of view. This work presents a framework for evaluating the financial consequences of player transfers as seen from a club's perspective. To this end, an objective player rating model is designed to rank players based on their contribution towards creating a positive goals differential for their team. The player ratings are combined as input to an ordered probit regression model, allowing the prediction of match outcomes as a function of the players involved in a match. Finally, Monte Carlo simulation is used to predict the final league standings, and thereby the financial gains obtained as a function of sporting success. The framework is illustrated on relevant player transfers from the 2014-2015 English Premier League season.

On the Dependency of Soccer Scores - A Sparse Bivariate Poisson Model for the UEFA European Football Championship 2016

Andreas Groll, Thomas Kneib, Andreas Mayr and Gunther Schauberger

Abstract: An important aspect for an adequate analysis of soccer data is to account for the correct dependence of the scores. After all, several recent studies have shown that, marginally, the scores of two competing soccer teams are (moderately) negatively correlated. It is easy to show that, if suitably structured linear predictors are chosen, a certain amount of (negative) dependence between the scores can be induced, even though, conditioned on the covariate information, independent pairwise Poisson distributions are assumed. A major objective of this talk is to analyze if this type of modeling is appropriate or if an additional explicit modeling of the dependence structure for the joint score of a soccer match needs to be taken into account.

For this purpose, a flexible bivariate Poisson model for the number of goals scored by soccer teams facing each other in international tournament matches is set up, including covariate information

of both competing teams. The model was estimated using the R-package "gamboostLSS" (Hofner et al., 2016; Mayr et al., 2012). With "gamboostLSS" the model family of GAMLSS (Generalized Additive Models for Location, Scale and Shape) is combined with the boosting estimation technique. It allows to use multi-parametric distributions in regression models in combination with implicit variable selection.

Based on all matches from the three previous UEFA European championships a sparse model is obtained: from a set of potential influence variables already used in Groll and Abedieh (2013) only three covariates, namely the "bookmakers' odds" (odds for winning the title before the tournament), the "market value" and the "UEFA points" were chosen. This model was then used to repeatedly simulate (1,000,000 times) all match outcomes of the UEFA European championship 2016 in France, resulting in winning probabilities for all participating national teams.

Home Team Advantage in English Premier League

Patrice Marek and František Vávra

Abstract: The home team advantage in association football is a well known phenomenon. The aim of this study is to offer a different view on the home team advantage. Usually, in association football, each two teams - team A and team B - play twice in a season. Once as a home team and once as a visiting team. This offers two results between teams A and B which are combined together to evaluate whether the team A against its opponent B recorded a result at the home field - in comparison to the away field - that is better, even, or worse. This leads to a random variable with three possible outcomes, i.e. trinomial distribution. Combination and comparison of home and away results of the same two teams is the key to eliminate problems with different strength of teams in the league. Using a uniform distribution as a prior we obtain a Dirichlet distribution as a posterior. This is later used to determine point and interval estimates of unknown parameters of the source trinomial distribution, i.e. the probability that the result at home will be better, even, or worse. Moreover, it is possible to test a hypothesis that the home team advantage for a selected team is statistically significant. This approach can be used to construct a measure of the home team advantage for a single team. Described procedure is demonstrated on English Premier League results from the 1992/1993 season to the 2015/2016 season.

SESSION 8-A: Tournaments and Scheduling

The Circle Method maximizes Carry-over

Erik Lambrechts, Annette Ficker, Frits Spieksma and Dries Goossens

Abstract: In 1847, Reverend T. Kirkman published a method that can be used for constructing a schedule for round-robin competitions. This method, that we call the Circle Method has been used abundantly in practice for many sports leagues around the world to construct schedules in round robin competitions. The following phenomenon is relevant in any round robin tournament. Imagine that your team is facing some other team in an upcoming match; we will argue that the opponent of this

other team in a previous match is relevant for the upcoming match. Indeed, if the team you're about to face has experienced a heavy loss in its previous match, the team may have a low morale, or be discouraged, and hence perhaps easier to beat. Then your team is receiving a so-called carry-over effect from the opponent of the team you're about to face. Of course, this effect may also work in an opposite direction. Thus, it is interesting to investigate the set of teams from which your team receives a carry-over effect throughout the competition. In one extreme case, this set of teams consists of all other teams. Then, in a single round-robin tournament, each other team gives once a carry-over effect to your team, giving rise to so-called balanced schedules. In another extreme case, only very few teams give carry-over effects to your team. This gives rise to schedules that can be perceived as unbalanced or even unfair.

In 1980, Russel proposed a measure that quantifies the extent with which a schedule is unbalanced; we call this value the carry-over effect value. This measure can be interpreted as a degree of fairness of a schedule.

It has been conjectured that the Circle Method generates schedules with a maximum carry-over effect; here, we show that indeed to be the case. Thus, our result can be succinctly stated as follows: The Circle Method maximizes Carry-Over.

Avoiding combinatorial clashes for the Champions Hockey League Group Stage Draw

Stephan Westphal and Martin Dahmen

Abstract: For the season 2016/2017, the Champions Hockey League (CHL) was performing a Group Stage Draw in which 48 teams had to be drawn out into 16 groups of three teams each. The allocation of the teams to the groups had to be done in a way such that teams coming from the same league were not drawn out into the same group. Furthermore, clubs from leagues where the national teams were participating in the final olympic qualification tournament could also not be drawn out into the same group.

At first, the 16 teams from pot 1 were drawn out into the groups A-P such that the first team drawn is assigned to group A, the second one to group B and so on. Then, the 16 teams from pot 2 were being drawn out in the same way, followed by the 16 teams from pot 3. But, whenever such an assignment would have led to two teams from the same league playing in the same group, the current group was skipped and the team was allocated to the next group in which it did not cause such a "league conflict". The same applied for assignment leading to "olympic qualification conflicts".

Whenever the assignment of a team to a group is not possible because it raises a league conflict or an olympic qualification conflict in this particular group, we will call this a "direct conflict". These are easy to see and can thus be prevented easily. But there are also "combinatorial conflicts" which are hard to detect. These are conflicts which arise when a team is allocated to a group in which it does not provoke any direct conflict but the set of remaining teams in the pots cannot be assigned without direct conflicts anymore.

Since the Draw was broadcasted live, the CHL needed to know immediately if an assignment would have led to a direct or a combinatorial conflict and to which group the teams had to be allocated directly after they have been drawn out of the pots.

In this talk we discuss the algorithm based on an integer programming model, which was used by the CHL for the 2016/17 Group Stage Draw.

Analysis of a Constructive Matheuristics for the Traveling Umpire Problem

Reshma Chirayil Chandrasekharan, Túlio A. M. Toffolo and Tony Wauters

Abstract: The Traveling Umpire Problem (TUP) is a combinatorial optimization problem concerning the assignment of umpires to the games of a fixed double round-robin tournament. The TUP draws inspiration from the real world multi-objective Major League Baseball (MLB) scheduling problem, but is, however, restricted to the single objective of minimizing total travel distance of the umpires. Several hard constraints are employed to enforce fairness when assigning umpires, making it a challenging optimization problem. This work presents a constructive matheuristic approach which focuses primarily on large benchmark instances. A decomposition-based approach is employed which solves Integer Programming (IP) formulations of the subproblems sequentially to arrive at a feasible solution for the entire problem. Currently, there exists no feasible solution in the literature for large benchmark instances of 26, 28 and 32 teams. The proposed algorithm is capable of efficiently generating feasible solutions for these large benchmark instances and improving best known solution for the only 30-team instance with known feasible solution, well within the benchmark time limit. Furthermore, the algorithm is able to produce feasible solutions to almost all small benchmark instances, albeit not to optimal ones. The solutions attained for these instances are competitive to those produced by other heuristic algorithms. The paper also outlines experiments conducted to evaluate various algorithmic design parameters such as size, subproblem overlap and penalty functions applied.

Scheduling an Indoor Football League: a Tabu Search Based Approach

David Van Bulck, Dries Goossens and Frits Spieksma

Abstract: The "Liefhebbers Zaalvoetbal Cup (LZV Cup)", is an amateur indoor football league founded in 2002 and situated in the vicinity of Leuven (Belgium). The LZV Cup focuses on teams that consist of friends and considers fair play of paramount importance. This league currently involves 477 teams, grouped in different divisions in which each team plays against each other team twice.

The goal is to develop a schedule for each of the divisions, which avoids a close succession of matches of the same team in a limited period of time. This scheduling problem is interesting, because matches are not planned in rounds. Instead, each team provides dates on which they can play a home game, and dates on which they can not play at all. Teams can use this list to avoid matches, e.g. during exams and holidays. Furthermore, in contrast to professional leagues, alternating home and away matches is hardly relevant in amateur leagues. The main reason is that the home advantage is quite limited since there are usually few spectators.

As the LSV Cup problem turns out highly demanding to solve with integer programming (Gurobi), we have developed a heuristic based on tabu search. The core component of this algorithm consists of solving a transportation problem, which schedules (or reschedules) all home games of a team. We used

this method to generate schedules for the seasons 2009-2010 till 2016-2017. Overall, the quality of the tabu search based heuristic is comparable to that of Gurobi, however, the reduced computation time and the absence of expensive software licenses make the heuristic implementation more suitable for (amateur) competitions such as the LZV Cup. These schedules were approved by the league organizers and have been implemented in practice, much to the satisfaction of the participating teams. In rare occasions where not all matches could be scheduled, the organizers appreciated that our approach outputs a partial solution and the conflicting teams to be contacted.

SESSION 8-B: Modelling and simulation

Compare the superiority of Japanese Collegiate Baseball Leagues

Takashi Toriumi

Abstract: The Tokyo Big 6 Baseball League (BIG6) and the Tohto University Baseball League (TOHTO) are the top two collegiate baseball leagues in Japan. Both leagues consists of six teams and are highly competitive; however, there is no opportunity for the teams in the two leagues to compete directly against each other except only in the final of the Japan National Collegiate Baseball Championship (NCBC). In this report, we calculate the strengths of six teams across both leagues and compare the superiority of them. We use data of matches conducted within the BIG6 (1088 matches), TOHTO (982), and NCBC (519) from 2001 to 2015 (30 seasons). Using the Bradley-Terry model, we estimate the strengths of each team in the two leagues as follows: 1) We estimate the strengths of 26 teams participating in the NCBC, including the number one teams in the BIG6 and TOHTO; 2) We estimate the strengths of the six teams in the two leagues based on the results in these leagues; 3) We match the strengths of the number one teams from the two leagues as obtained in step 1 and the strengths of teams as obtained in step 2; and 4) We standardise the strengths of the other teams in the two leagues according to the measure applied in step 3. The results of step 1 indicate that the number one team in the TOHTO had the highest strength of 0.1882, followed by the number one team in the BIG6 at 0.1166, among the 26 teams. The results of step 4 indicate that the corresponding strengths of the first-ranked to sixth-ranked teams are as follows: 0.1166, 0.0630, 0.0430, 0.0310, 0.0172, and 0.0023 in the BIG6 and 0.1882, 0.0599, 0.0456, 0.0309, 0.0218, and 0.0138 in the TOHTO. On comparing the strengths of the same rankings in both leagues, the strengths of the first and sixth teams in the TOHTO are higher than those of the corresponding teams in the BIG6, while the strengths of teams ranked second to fifth in the two leagues are comparable. Thus, it can be concluded that the TOHTO is superior to the BIG6.

Optimization of Harmony in Team Formation Problem for Sports Clubs: A real life volleyball team application

Gerccek Budak, Imdat Kara, Yusuf Tansel İç and Refail Kasimbeyli

Abstract: Sports team coaches' main concern is forming the best team to win the upcoming

match. Even if a team squad is comprised of limited number of players, the combination of them makes out a complicated problem with huge number of possible line-ups. Researches on this subject increase in the last decade since this decision problem became important financially and solvable as the parameters are reachable. There are many aspects that define the best team such as team harmony, player performance, team strategy, opponent suitability etc. We propose a new mathematical model which aims to form the best team on the perspective of maximum team and player harmony. The proposed mathematical model supplies a team that total satisfactory level of the all assigned players is the highest. Harmony parameter is obtained from players by using questionnaires. A real life application of the proposed model is presented on volleyball team formation problem in the study as well.

On competitive balance and scoring rates in international rugby union

Phil Scarf and Rishikesh Parma

Abstract: We look at the development of scoring rates in Rugby Union since 1960 and in relation to this make some observations about competitive balance in this sport, and in team sports in general. In particular, we investigate the relationship between match outcome (win, draw, loss) probabilities and scoring rates in a "double Poisson match", a match in which competitors scores follow independent Poisson distributions. We also look at the effect of introducing some score dependence on this relationship. If one accepts that uncertainty of outcome (competitive balance) is important to the consumers of sport, then it is important that sports administrators recognise that ceteris paribus more scoring implies less uncertainty of outcome. Therefore, the modification of rules so that scores become more frequent may make a sport less appealing to its audience.

Learning to Rate Player Actions on the Example of Soccer

Uwe Dick and Ulf Brefeld

Abstract: The evaluation of individual player actions in soccer is essential for analyzing game plans as well as team and player performances. Player ratings are however often based on game-aggregated individual statistics such as the number of completed passes or tackles. Thus, their impact is limited and mainly used for entertainment while key performance indicators for professionals (e.g., scouts and coaches), such as the impact of a player on the execution of a particular offensive pattern or in countering the opponent's built-up play via intelligent space management, are ignored.

We propose a deep convolutional architecture that automatically learns situation-related performance measures using trajectory data from first-flight football games. To train the network, ground-truth is extracted from event-streams so that tackles, shots, and passes from both teams serve as additional input variables. The network leverages the data and learns to rate player actions as well as team-wide player positioning and movements.

The proposed deep neural network draws from recent advances in machine learning. Deep learning methods have already shown exceptional performance in identifying abstract concepts in game-related [1] and visual domains [2]. We combine these two worlds and propose a deep neural architecture that learns to identify movement patterns and pass sequences from trajectory data that help teams to

improve their chance of scoring goals. We visualize the derived metrics and show how individual player actions change the predicted outcome of repeating game situations.

[1] Silver et al. Mastering the game of Go with deep neural networks and tree search. Nature, 2016.

[2] Bernardi et al. Automatic Description Generation from Images: A Survey of Models, Datasets, and Evaluation Measures. 2016

SESSION 9-A: Strategy

Tactics for T20 Cricket

Tim Swartz

Abstract: This talk begins with the fact that Twenty20 cricket is a different game than one-day cricket, and then conjectures that Twenty20 may benefit from alternative strategies. We explore two avenues for the modification of tactics in Twenty20 cricket. The first idea is based on the realization that wickets are of less importance in Twenty20 cricket than in other formats of cricket A consequence is that batting sides in Twenty20 cricket should place more emphasis on scoring runs and less emphasis on avoiding wickets. On the flip side, fielding sides should place more emphasis on preventing runs and less emphasis on taking wickets. Practical implementations of this general idea are obtained by simple modifications to batting orders and bowling orders. The second idea may be applicable when there exists a sizeable mismatch between two teams. In this case, the weaker team may be able to improve its win probability by increasing the variance of run differential. A specific variance inflation technique which we consider is increased aggressiveness in batting.

Optimising a Batting Order in Limited Overs Cricket using Survival Analysis

Patrick Brown, Ankit Patel and Paul Bracewell

Abstract: Several within game metrics exist to summarise individual batting performances in cricket. However, these metrics summarise individual performance and do not account for real time nor partnership performance. Previous research has successfully formulated models capable of calculating how likely a partnership is to survive each ball, for different partnerships based on within-game events. Those results are extended to optimise batting order. An expectation of how likely a batting partnership is to survive each ball within an innings can aid the development of more effective partnership strategies to optimise a team's final total. Using Cox proportional hazard models, each New Zealand partnership was assigned a measure of effectiveness. This measure of effectiveness was used to optimally position New Zealand batsmen. New Zealand captain, KS Williamson, is suggested as the optimal batsman to bat in position three regardless of which opener is dismissed. Reviewing New Zealand's loss against Australia on 4th December 2016, indicates a suboptimal order was used with JDS Neesham and BJ Watling batting at four and five respectively. Given the circumstances, C Munro

and C de Grandhomme were quantified as a more optimal order.

Round-Robin Tournaments with Limited Resources

Dmitry Dagaev and Andrey Zubanov

Abstract: We study strategic foundations of players' behavior in a round-robin contest environment. Round-robin structure of a tournament means that participants are sequentially paired to play against each other, and all prizes are distributed according to the aggregate ranking at the end. The latter feature distinguishes a tournament from a sequence of independent games and brings specific participants' behavior patterns. In most real-life round-robin tournaments such as FIFA World Cup group stage, participants are exactly maximizing the expected payoff after the completion of the tournament (e.g. number of wins or points) rather than just payoffs of separate games.

We consider a model of a round-robin tournament with three participants and perfect information, where each match between two teams is a contest. Following the literature on contest theory, we take participants' efforts as their resources. Participants decide on how to spend these resources during the tournament. This question is closely connected to a classical Colonel Blotto game, in which each of two opposing colonels must distribute their soldiers between several battlefields. We analyze the effect of changes in cost of resources, resource constraints, and payoff structure on distribution of efforts and player's utilities in round-robin tournaments.

We analyze cases of a first-price sealed-bid auction and a Tullock lottery specification and we solve them for a pure strategy subgame-perfect Nash equilibrium, or, when impossible to find in a closed form, solve for it numerically. We pay special attention to comparative statics of the model where we derive how strategies and equilibrium payoffs depend on distribution of prizes and sensitivity of contest outcome to efforts of players. Our results on the first-mover advantage phenomenon in round-robin tournaments are different from the previous that considered another model specification (Krumer et al, 2015).

SESSION 9-B: Performance and data analysis

An analysis of characteristics of soccer teams using a Markov process model considering the location of the ball on the pitch

Nobuyoshi Hirotsu, Keita Inoue and Masafumi Yoshimura

Abstract: In this paper, we propose a statistical model of a soccer game that is useful to provide insights of characteristics of teams, based on a Markov process model considering the location of the ball on the pitch. Using this model we analyze their characteristics related to such factors as home advantage, offensive and defensive strength and their interactions, in terms of goals and possession according to the location of the ball. We divide the pitch into 9 areas, and collect the data in terms of the change of location of the ball, together with the change of possession of the ball. Using this method, we analyze the characteristics of teams based on annual data from the J-League Division 1

in 2015 and illustrate their characteristics in ways that allow us to visualize offensive and defensive strength, preference for playing at home and preference for particular opposition teams, according to the location of the ball on the pitch.

Dynamic Sport Performance Indicators with Application to Italian Basket League

Andrea Artico, Mario Bolzan, Livio Corain and Luigi Salmaso

Abstract: Since scores of the sport players and teams fluctuate over time, suitable time-based performance indicators and modelling are demanded either for descriptive and explicative-prediction purposes. Based on the concept of multivariate stochastic dominance, the aim of this work is to propose a nonparametric and permutation-based framework for modelling, testing and ranking on multivariate time sport data. The proposed methodology provides a flexible and less demanding in terms of underlying assumptions tool to infer on the presence of possible stochastic dominances that may take place among a set of several multivariate populations, i.e. teams, set of players or just single players. Via a Monte-Carlo simulation study we investigate the properties of the proposed testing and ranking method where we prove its validity under different random distributions and type of dependencies and correlation structures. From the practical point of view, the proposed methodology can be effective to face some real problems in Sport Performance Analytics. Finally, we present an application to Italian Basket League.

Bayesian hierarchical models for predicting individual performance in football (soccer)

Leonardo Egidi and Jonah Gabry

Abstract: In most of the published statistical research on football the authors primarily focus on modeling some aspect of the global result of a match between opposing teams (e.g., goal differential), and rarely on the performance of individual players over the course of a season. One reason for not focusing on predictions at the individual player level is that the performance of individual football players is noisy and hard to predict and many factors contribute to the predictive challenge. Nevertheless, we suspect that even in football —in fantasy football at least— a prediction task for individual performance could be well posed. In this paper we present and critique several Bayesian hierarchical models designed to predict the results of an Italian fantasy football game with players nested within position and team. All models are estimated via Markov chain Monte Carlo using RStan, the R interface to the Stan C++ library. The outcome of interest is the fantasy rating of each player in Italy's top league, Serie A, for each match of the 2015–2016 season. In some sense, we are using these data with a dual purpose: we would like to provide estimates and predictions both for the fantasy game and for the sport itself. That is, we use the fantasy ratings as both an outcome of interest and also as a (crude) proxy for the quality of a player's performance. Although we take an Italian fantasy football product as our example, the process of developing these models and comparing them on predictive performance does not depend on the idiosyncrasies of this particular fantasy system and is applicable

more broadly. Our central goals are to explore what can be accomplished with a simple freely available dataset (comprising only a few variables) and to focus on a small number of interesting modeling and prediction questions that arise.