A Graded Concept of an Information Model for Evaluating Performance in Team Handball

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Abstract: Although team handball is a very popular sport in Europe, computer science did almost completely ignore that area in the past. This article introduces a graded approach for an information model that allows to express the effectiveness of a team as well as of single players, thus providing a basis for information-based decisions of coaches, as well as for applying analytical methods. From this perspective, the article is an early step to further introduce digitalization via a data model into a very classical sports area, however, introducing mechanisms that take into account the available degree of digitalization.

1 INTRODUCTION

Team handball is a very fast game with full physical contact of the players who are not wearing any protectors. The goal rate easily exceeds one per minute. That is one of the reasons why it has become a pretty popular game in Europe. In Germany about 750.000 people are playing handball in multiple leagues (DHB, 2019). The first German league (Handball Bundesliga) has an annual budget of approximately 80 million Euros. The top leagues in France and Spain even exceed that number. Top teams in France for instance, have an annual budget between 17 and 18 million Euros (DPA, 2016).

Although we can recognize an increasing usage of computer science methods from analytics and Big Data (Morgulev et al, 2018), this is usually restricted to the premier leagues of sports areas with huge annual budgets—far beyond the previously mentioned figure. Hence, team handball is just at the starting point of digitalization. So far, there is almost no usage of sensors to automatically collect data of the players—particularly not during a game. Even the official game reporting of major leagues just recently switched to an online platform as a first step into digitalization (DKB HBL, 2019). Thus, third party providers are offering a service to collect and provide game information based on the manual collection of data, called scouting (Sportradar, 2015).

Since video based collection of information like in football (ChyronHego, 2016) is too expensive and sensor based information collection (Kinexon, 2017) is not yet applicable due to the size and complexity of the equipment, automated information collection is rather rare in case of team handball. Hence, there are only some cases for which information of real handball games have been collected. Even worse, with the absence of collected information there is also an absence of insights based on the collected information. As a consequence, so-called player effectiveness indexes (PEI - also called player value indexes) are only at their beginning for team handball. Currently, there are almost only trivial data models that allow to evaluate the player performance and only some advances have been made just recently (e.g. (Wagner, 2014)). Thus, team performance is mostly evaluated based on the experience of coaches rather than on objective, information based indicators.

Furthermore, due to the fact that the effectiveness indicators are missing, young potentials are hard to identify and the development of potentials is very hard to track. Currently, this area is also dominated by the intuition of coaches and scouts.

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2 BASICS OF THE MODEL

Before defining an actual effectiveness indicator (which is just a domain specific performance indicator), it is crucial to understand the most important principles of the domain area — team handball in our case (Brand, 2008). We can start with a few simple observations. The overall objective of a team in a game is to win the game by scoring more goals than the opponent team. Hence,

- scoring goals is considered to be positive.
- any activity to help scoring a goal for the own team is considered to be positive. These activities are called offense activities.
- receiving goals is considered to be negative.
- any activity preventing the opponent team to score a goal is positive. These activities are called defence activities.
- losing possession of the ball is negative because a goal can only be scored when possessing the ball.

2.1 Direct Offense Activities

To actually score a goal, it is necessary to possess the ball and to throw the ball at the goal (also named shot). This is called a scoring attempt. Three outcomes are differentiated when a scoring attempt occurs: success, miss, and a defended shot. Besides throwing the ball at the goal, players can also pass the ball to another player and errors can occur while passing balls, leading to a loss of the ball: bad pass.

2.2 Direct Defence Activities

The major objective of the defence is to prevent the opponent team from scoring goals as well as getting the ball. The following events are differentiated in case of the defence: steal, block, and save (goal keeper). All events that lead to the possession of the ball are additionally categorized as turnover events.

2.3 Rule Violations

In general, it is allowed to interfere with an opponent. The referees decide whether an interference was according to the rules (no whistle), or whether there was a violation of the rules: foul (IHF, 2018). In case of a violation of the rules there is a whistle and the violating team loses the ball (aka technical error). Furthermore, depending on the severity of a foul there can be an additional sanction (and combinations thereof).

2.4 Player Position and Movement

Players can move arbitrarily on the field, but they are neither allowed to run over a non-moving opponent player nor to step on the penalty area (except for goal keepers). Overall, in our information model every player has an associated 5-tuple (n, l, w, d, s) which describes the players number n, the current position, expressed as two coordinates l and w, the direction d, and the speed s of the player. The position and movement of the ball are modelled with a similar approach, having the number -1: (-1, l, w, d, s) and d set to the movement direction of the ball.

In team handball, players can be substituted at any point in time. However, there are some rules regarding the substitution procedure. Violating the rules results in a sanction of the violating player. Having the objective to define a player effectiveness index, we need to distinguish players who are currently playing from players on the substitution bench. If players are currently on the match field, they are called active If they are currently on the substitution bench, they are called inactive.

3 EFFECTIVENESS INDEXES

Given the model elements of the previous section Basics of the Model, effectiveness indexes can be defined based on these model elements. However, there needs to be a detection of the model elements themselves as well as of combinations (composites) in order to compute an effectiveness index that is based on them. The following sections will describe the options based on the ability to detect the events.

3.1 Lowest Level Index

Even the lowest level leagues of team handball in Germany have to keep track of a set of basic events during a game in order to prepare an official game report that allows to prove the outcome of a match. The following data are recorded:

- Team players: no distinction of active and inactive
- Goal events: who scored when
- Sanctions of players: who was sanctioned and when

There is no recording of further events, positions or movements. Thus, only a very simple index can be derived from this information just based on the fact that scoring goals is positive and being sanctioned is negative. A player can earn a certain number of

credits by scoring a goal and a player can lose credits by being sanctioned. Hence, this is not a very useful index. However, in many cases we do not have more information than just the official match report.

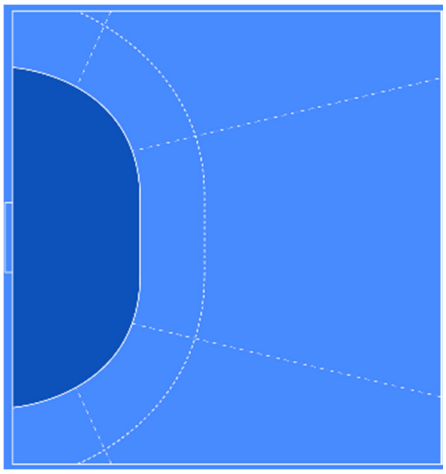

Figure 1: Zones to record a scoring attempt.

3.2 Single Player, Outcome-based Index

The next level of detail of tracking events of team handball was introduced by companies collecting information for betting (e.g. (Sportradar, 2015). Since betting service providers are getting payed for offering a continuous information stream regarding team handball matches, they are paying human observers, so-called scouts, to record events during a game.

The event recording is done manually using a computer-based tool that sends the events online to a platform which is then used by the betting companies (DKB HBL, 2019). The concept has been adapted by the upper leagues in Germany like the Bundesliga as well as by the European and the International Handball Federation for international matches.

Since humans can only record a limited set of events, basically, only events are recorded that either result in a goal or in a turnover. The position of an attempt to score a goal is also recorded but only based on 8 sectors (see figure 1). Therefore, the following information is available in addition to the approach of the lowest level index, if the event results in a turnover (and ends the current attack):

- Miss events: shooter with sector and time
- Steal events: defender and time
- Block events: shooter with sector blocking player and time
- Save events: shooter with sector, goal keeper and time

This introduces at least some information regarding defence players and goal keepers. Thus, allowing to earn credits for offense actions like scoring but also for defence actions like saves and blocks (Menz, 2017). In addition, there are approaches for indexes introducing penalties for non-successful scoring attempts as well as the concept that the amount of credits gained or lost depends on the sector from which the scoring attempt was made (Thiele, 2017). Due to the ability to differentiate offense from defence actions, we can also introduce two separate indexes in which we aggregate the corresponding credits: an offense index and a defence index. The overall effectiveness index is then the aggregation of the two.

Unfortunately, there is still no information recorded that allows to determine which players are active at a certain point in time. Although only the active players of a team should be able to earn credits when a goal is scored or prevented, the collected information does not allow that distinction. Thus, current approaches focus only on the players directly involved when an event occurs.

The limitations of the indexes in this section are again due to the limited information that is manually collected by the scouts. This is mainly caused by the limited capacity of humans to record the events. The available capacity is currently spent to collect information symmetrically for both teams of a match. If that approach is changed to mainly focus on one team only (for each team) an enhanced index becomes possible. For instance, it can be recorded which player of the own team was involved when an opponent player was sanctioned. Thus, adding credits to the offense index of the player who was the fouled because sanctioning of an opponent player is beneficial for the own team.

3.3 Active Player, Outcome-based Index

Neither scoring goals nor preventing goals in team handball can be usually achieved by a single player. Thus, all active players contribute and should receive credits accordingly. I.e., as soon as we can detect who is active when an event occurs, we can also add credits to the index of the rest of the active team members and not only to the directly involved player, based on an assumed degree of contribution (Thiele, 2017) and (Uhrmeister et al, 2019).

A direct consequence of being able to distinguish between active and inactive players on the level of the effectiveness indexes is, that the index of currently active players can be compared with their own

indexes of the past (expected index value) as well as with historical indexes of currently inactive players, which can be used as an information to base substitution decisions on (regarding which active player to substitute by which inactive player).

However, keeping track of player substitutions in team handball is very exhaustive and needs two additional scouts if done manually. Since this is much too costly, we are in the process of evaluating a cheaper sensor-based approach to detect a substitution automatically, which is then just used as additional input that is merged with the asymmetric scouting information. Thus, allowing to detect which player becomes active and which player becomes inactive.

3.4 Active Player, Contribution-based Index

The previously described indexes did not take any individual contribution into account except for the activity of the finally involved player. Since team handball is a team sport, these approaches ignore a crucial aspect of a team sport: the team coordination of the activities of players. That means that there might be very valuable players without being directly involved in the recorded events.

The reason why this information is not considered, lies in the fact, that it is not decidable if a certain activity of a player will be connected to a future scoring attempt or whether it will prevent a future goal respectively. Only by the concept of backtracking after a scoring attempt (or turnover without a scoring event) it can be determined whether there was a direct connection or not. Furthermore, it is necessary to observe the activities of all players in parallel, which can only be achieved using modern sensor technology.

In case of the contribution-based index introduced in this section, we assume that we can track the position and movements of players (and the ball) as described in section 2. using current sensor technology with modern computer equipment, as in case of IoT scenarios. There are multiple vendors offering solutions in these areas.

3.4.1 Potential Scoring Probability

If we recall the discrete positions of a field depicted in Figure 1, then we can associate a scoring probability with each of the cells (see Figure 2). The initial scoring probability is the probability to score a goal when no defensive player except the goal keeper can interfere. The defence players can reduce this probability by getting in between the shooter and the goal and even further by getting in physical contact with the shooter (see also section 3.4.3).

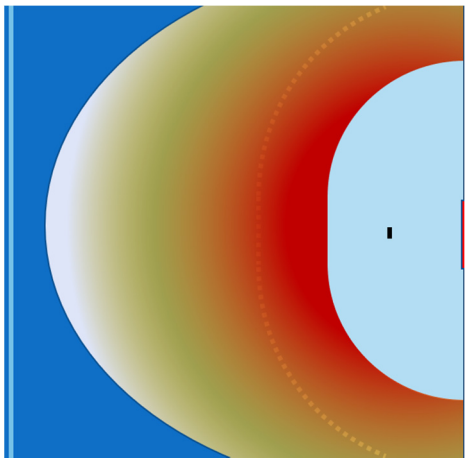

Figure 2: Potential scoring probability.

In case of the contribution-based index, we assume that the position of players can be detected, and a potential scoring probability can be computed.

For a further advanced model, a specific potential scoring probability distribution can be defined for each player. Thus, allowing to consider the different player abilities. For instance, a wing player usually has a high probability from the sides of the field but a relatively low probability from the central back (see Figure 3).

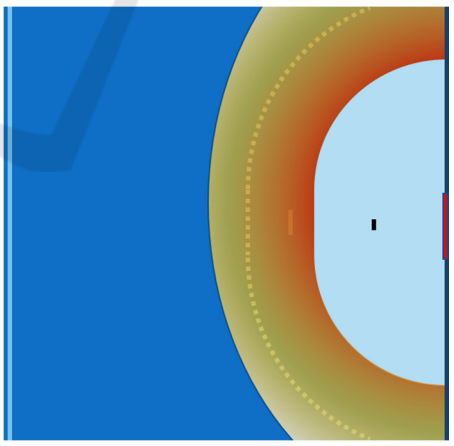

Figure 3: Player specific scoring probability.

3.4.2 Player Move Segments, Team Moves and Team Tactics

To have just the raw positions and movements of players does not actually allow to determine the value of the movement activity. For that purpose, we need

to combine the movements to segments which consist of a starting cell and an end cell, meaning the player has moved from the starting cell to the end cell. The segments are usually characterized by the fact that the player starts moving at the starting cell and keeps the general direction and speed until he or she reaches the end cell. I.e. a significant change of the speed or the direction of a player ends the current segment and starts a new one.

Particularly offense tactics combine the segments of multiple players and passes to an overall team move that usually even has a specific name (e.g. “Sperre-Absetzen” which is similar to “pick and roll” of basketball) and is explicitly trained (Brand, 2008). Key is, that a team move is a certain, in general parallel, combination of segments of multiple players. The set of moves which a team can perform is also called the team tactics. There are team tactics for offense as well as for defence. We assume that movement segments of players can be detected by a relatively simple interpretation of a player’s position and movement information. Furthermore, we assume that we can even detect passes, which depends on the used sensor technology and the used ball respectively. Team moves are expected to be detectable soon by using analytics and deep learning mechanisms based on video streams.

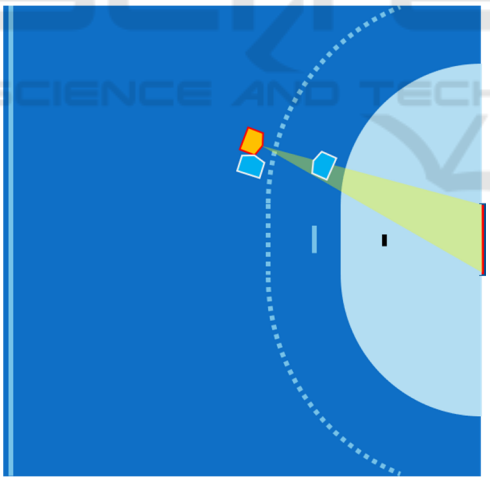

Figure 4: Pressure situations.

3.4.3 Concept of Pressure and Its Prevention

The concept of pressure in team handball is defined based on the potential scoring probability of a position. Pressure has the objective to reduce the scoring probability of a position when an offense player is located at that position. A defence player can reduce this probability by moving in the area with a direct line between the position and the goal (see Figure 4). Multiple defence players can further reduce the scoring probability by combining their efforts by a team block or defensive wall (in case of a free throw) to cover the complete area.

The scoring probability of a position is similarly reduced by the physical contact of a defence player with an offense player being at the position, while the defence player is not in a line between the position and the goal (see Figure 4). I.e. the defence player has a distance of up to two field cells to the position. The highest reduction of the probability by a single defence player is caused by being in direct contact distance while standing in the line to the goal.

To prevent the pressure by a defence player, offense players hinder the defence player to move in the line between a position and the goal and from getting close to a position respectively, by blocking the way. I.e. there is no single move segment that allows the defence player to interfere without running over the preventing player.

3.4.4 Assessment of Offense Activities

The basic idea of the contribution-based index is that players earn credits when even contributing only indirectly to a scoring attempt. This means, that in addition to the credits earned in case of the outcome-based indexes, further credits can be earned. The following activities of players lead to additional credits (presumed that the activities can be detected):

- Passing the ball to the player who attempts to score if the ball receiving player had a position with a higher potential scoring probability (sometimes called assist)
- Having a position on the field which prevents an opponent player from causing pressure (barrier) on the attempting player.
- Having a last movement segment that increased the scoring probability of the position of the player, thus increasing the threat on the other team.
- Participation in the last detected team move of the same attack that ended in the scoring attempt (tactical participation).
- Being the fouled player if the defence player is sanctioned.

An offense foul and technical errors lead to a loss of credits.

3.4.5 Assessment of Defence Activities

Players can also earn credits in addition to the direct defence activity related credits (steal, block, and save) by positioning themselves appropriately when a

scoring attempt by the opponent team is made. Players earn defence credits for:
Having a position which decreased the scoring probability of another attacking player. The more the scoring probability is reduced, the more credits are earned (threat reduction).

- Preventing a goal after a team move of the offense team. (tactics response)
- Interrupting an attack by a foul or getting the ball out of play without a sanction (interrupt)
- Being in the direct line between the attempting player and another offense player with a higher scoring probability (pass prevention)

Being sanctioned leads to a loss of credits.

3.4.6 Overall Index Calculation

Whenever there is a turnover or a scoring attempt, the indexes are updated. For each player, the offense credits and the defence credits are determined and then aggregated to the offense index, the defence index as well as to an overall index which gives an indication of the effectiveness of players. It is obvious that inactive players cannot earn credits in case of the contribution-based index. The credits can even be aggregated on a team level.

We do not go into details regarding the aggregation at this point, because we assume that the calibration (see next section) will reveal criteria for deciding on the appropriate method for aggregating the credits. However, we assume that weighting factors are needed rather than using just a linear summation.

3.4.7 Calibration

A key aspect of almost all the indexes and particularly of the contribution-based index is the amount of credits that can be earned or lost in each of the cases as well as the used aggregation function. The actual contribution weight of each activity that leads to credits heavily depends on the domain of team handball. Thus, an in-depth calibration phase is needed to assign the appropriate amount of credits to the described activities.

By using a first pair-wise comparison, a starting point for the calibration can be derived:

- The value of scoring a goal is similar to either a steal, save or a block with a turnover.
- In case of offense, increasing threat should have the lowest value followed by the barrier and the assist on the same level. The value of tactical participation should be similar to the value of increasing threat and being fouled with a sanction.
- An offense foul or a technical error should result in a loss equivalent to the value of a barrier.
- Pressure by moving in between the line of an attacking player and the goal should have the lowest defence value. The pass prevention should have a similar value.
- Pressure by contact should have a higher value than the pass prevention but lower than the save or a block without a turnover which again have a lower value than a steal.
- Being sanctioned should result in a loss equivalent to a block without a turnover.

These rules can be depicted on a simple point earning system using the straight-forward summation as the aggregation. Whether this will lead to results that are like domain experts' opinions needs to be determined and the credit model needs to be adapted accordingly.

4 CONCLUSIONS

This paper has introduced a concept of an information model that allows to calculate an effectiveness index for team handball players as well as whole teams based on earning or losing credits for certain activities.

The presented approaches heavily depend on the information collected during a match and it has been shown that some information cannot be collected by humans as it is done exclusively today. Thus, the introduction of digitalization in the context of the information collection in team handball is very likely to have a significant impact on future decisions of team handball coaches not only during games but also regarding training of players and team management.

To collect the necessary data for the introduced contribution-based index we are currently investigating a combination of passive RFID based technology, as well as active sensor technology and near-line video stream analysis. Even though we assume that the automated team move detection in team handball will probably need a few more years of development, the structure of the index concept allows to start without that technology and to include that part at a later point in time when it becomes available.

It is important to notice, that the work presented is at the concept level. Still, several details need to be worked out. However, the explicit description of the concept has helped to convince the application area, the team handball community, that introducing IT concepts and methods is not just a current hype but make sense and can actually help to get decisions in

team handball to a new level. Additionally, the introduction of the indexes and the collection of the additional player information allows the application of analytics in order to find patterns which help to improve teams.

A side effect of explicitly expressing the value of activities is the understanding of the game and allowing to simulate as well as analyse game situations, which was too complex for human beings in the past. It is very likely that this will generate new insights in the future - particularly in the context of team moves and tactics.

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