Analysis of Curling Team Strategy and Tactics using Curling Informatics

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Abstract: The 2015-2016 season became a historic season for Japanese curling. Japan national curling team has won a silver medal for the first time at the 46th Women's World Championship 2016 in Canada. However, it is still necessary to work on strengthening the team performance in order to aim for the top. Such strengthening needs to include material factors such as the physical factor and the human factor, but also the strategic/tactical factor which is crucial in curling. Bradley (2009) points out the strategic/tactical factor as the most important at top level. As an example of a research aimed at supporting such strengthening of the strategic/tactical factor, Masui et al. (2016) proposed the concept of Curling Informatics. They built an environment for strategic/tactical support which makes use of ICT by allowing digitally collect and analyze game informations in real time. Specifically, as the first step of implementation they developed a digital scorebook *iCE* as a method for digital collection of game information for further analysis. In this research we analyzed game information collected with *iCE* to establish the effective analysis for tactical support and verify the knowledge which can be obtained empirically and what kind of new knowledge can be obtained from it. We report on the new knowledge we obtained regarding the relationship between shot accuracy and difference in game scores, and difference in correlation for each level in 93 games collected during the 2013-2014 season.

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1 INTRODUCTION

Japan national curling team won second place at the Women's World Championship 2016 in Canada, Saskatchewan. It was the first time a Japanese team won a medal in curling. In the background of this success, there are various strengthening programs developed for Japanese curling (Yanagi, 2011; Takahashi, 2011).

However, it is still necessary to continue working on strengthening such support in order to make Japan capable of obtaining a gold medal at the Pyeongchang Winter Olympic to take place in two years. For example, Japan played against Switzerland three times including round robin[1]. This suggests that Japan should have already captured the tactics of Switzerland team which should help in winning a gold medal or at least improve the team's ranking during the Pyeongchang Winter Olympic in 2018 .

[1]Type of a tournament in which every team competes against every other team in turns.

An Information Science approach can be mentioned as an example of a method for improving the performance of a team. In the past few years a number of cases to support sports with ICT (Information and Communication Technology) have been reported (Fujimura, 2004; Kagawa, 2006), including curling (Masui, 2016).

Masui et al. (Masui et al. 2016) have proposed a new field called *Curling Informatics*. As Figure 1 shows, this research field deals with the strategic and tactical factors of top curling teams and improves the strategic and tactical skills of curling players. It also focuses on realizing several support environments, such as recording and referring to game information, tactical navigation, and assistance for reflection and tactical training. Specifically, general plan developed within this field aims at implementing the following methods to (1) collect, (2) analyze, (3) visualize and (4) share game information. In the first step, they developed the digital scorebook *iCE* which runs on a tablet computer to collect and analyze game information and they confirmed validity of the system. By

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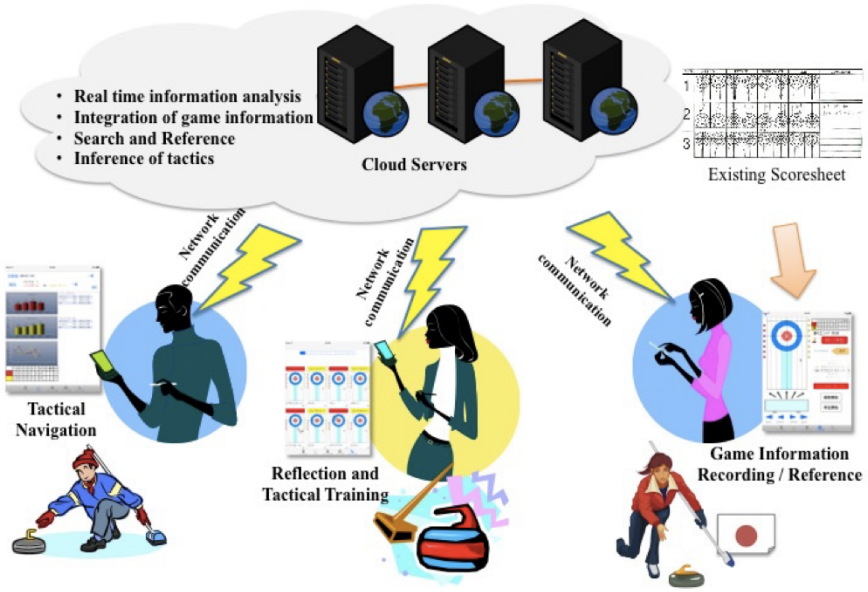


Figure 1: The concept of Curling Informatics.

the application of *iCE*, it is possible to check the shot accuracy of each team or player based on collected information sequentially and visually. In the near future, they plan to analyze game information stored with *iCE* in detail.

As a part of Curling Informatics, in this study we manually analyze game information with the aim to specify the team's characteristics and establish the appropriate analytical method. Especially, we discuss the influence of shot accuracy against the game result by focusing on the relationship between shot accuracy and score.

The outline of the paper is as follows. Firstly, we describe the team strategy and shot accuracy in Section 2. Next, we describe an overview of targeted game information, and the analytical method. The results are discussed and explained in Section 4. Finally, in Section 5 we conclude the paper.

2 TEAM STRATEGY/TACTICS AND SHOT ACCURACY

Curling is a winter sport in which two teams compete to obtain points by throwing 16 stones at the center of a circular area called a *house* in an ice-based square area called a *sheet*. One team consists of four players. Each player throws two stones (called *shot*) in a rotation, and the score is calculated by each rotation, when all 16 stones have been thrown. At this time, The team that has a stone at the nearest position to the center of the house gets the number of points equal to the number of stones on the inside of the opponent's stones in the *house*. The scoring team has the first move in the next rotation.

This rotation is called an *end*. One game consists of eight or ten ends, but the game is extended if the score is tied in the final end (Howard, 2009; Coleman, 2014).

In addition, Curling is often called "chess on ice" because it is a kind of sport in which tactics is very important. It requires a player to form complex strategies in search for effective moves with consideration of the ice condition and stone position in the *house*.

Shots in curling are roughly divided into two types: *draw shots* and *takeout shots*. In *draw shots* the stone stops in the *house*. *Takeout shots* force opponent stones out of the *house*. The thrown shot is recorded by a team coach or a substitute player and is given from 0 to 4 points. In the special case that affects the position, such as takeout shot which hits more opposite stones then advised by the skip, 5 points can be given. These points are called "*shot-score*" in curling. Additionally, shot accuracy is calculated. Shot accuracy is the percentage that represents the overall accuracy of the shots and is based on *shot-score* of each end or the whole game, according to equation (1) and is one of important measurements to estimate player's skill and condition.

$$shot\ accuracy = \frac{total\ of\ shot - scores}{number\ of\ shots} \times 25(\%) \quad (1)$$

In general, the higher accuracy shots there are, the more accurately the team was able to throw shots. Therefore, it is advantageous in the game. The team

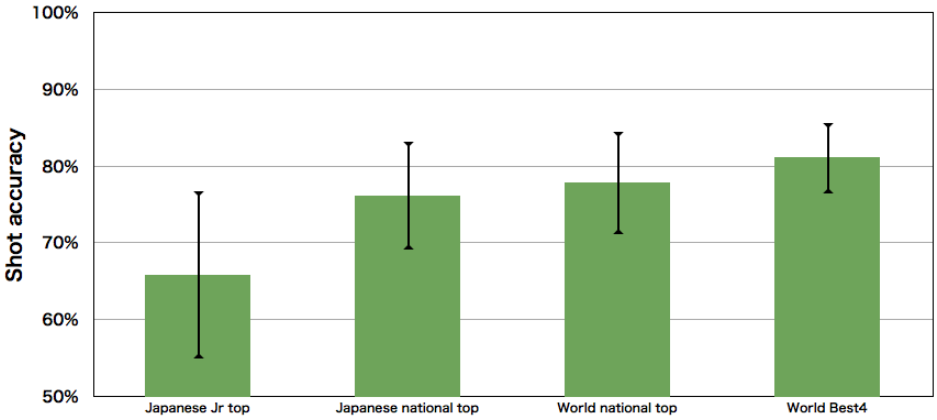


Figure 2: Shot accuracy for each level.

which has higher shot accuracy is more likely to succeed when drawing the shot in critical situations. And the team which has lower shot accuracy will raise the probability for scoring by opposite team.

iCE compiles shot score databases from basic data of shot accuracy, which makes it possible to organize and analyze scores from a variety of viewpoints. To grasp the characteristics and trends for each teams we could analyze this information on shot scores in more detail. And this in result could lead to finding the difference of strategy between a rival country and Japan in an objective way.

Masui et al. (Masui et al. 2016) suggested that there is a strong correlation between the difference in shot accuracies and the difference in the game scores. In addition, they observed that Japanese national class is stronger than Japanese junior national class. And Japanese national class is rarely influenced by missed shots. It means that the game result could be predicted before the game ends if we knew the difference in the playing teams' shot accuracy. Furthermore, the correlation in world class becomes weaker than Japanese national class because of smaller differences in shot accuracies.

3 METHOD AND TARGET DATA

To verify the analysis of Masui et al. (Masui et al. 2016) mentioned in Section 2, we analyzed the relationship between difference in shot accuracy and score for game information of world class teams.

Specifically, we extracted the difference in scores and shot accuracy for each collected game. Next, we calculated the difference in shot accuracy and Pearson's correlation coefficient based on extracted data. In addition, we examined a correlation between difference in scores and difference in shot accuracy.

Table 1: Target game information for analysis.

Year	Championships	Number of games
2012	30th Japan Championship	26
	PACC Japan Palyoff	16
	Pacific Asia Junior Championship	20
	World Junior Championship	11
	3th College Championship	10
	Universiade 2013 of Japan Playoff	7
2013	Japan Junior Championship	24
	31th Japan Championship	11
	Olymipic Winter Games of Japan Playoff	21
	4th College Championship	11
2014	5th College Championship	13
	Universiade 2015 of Japan Playoff	30
	Advics Cup	13
	Sochi Olympic Winter Game	93
2015	World Woman's Championship	72
	Total	378

The target data is the game information in the database for 285 games collected by Masui et al. (Masui et al. 2016) and 93 games of Olympic Winter Games 2014 (total of 378 games, covering around sixty thousand shots). Table 1 shows target game information for analysis in detail.

4 RESULT AND DISCUSSION

In this section, we describe the relationship between difference in shot accuracy and difference in scores. Figure 2 shows team shot accuracies for 285 games collected by (Masui et al. 2016). In Figure 2 , the X axis shows level, the Y axis shows shot accuracies each game and the Error bar stands for standard deviation. As shown in Figure 2, higher level teams achieve higher shot accuracy and lower standard deviation. In addition, we calculated Pearson's correlation coefficient between difference in shot accuracy and difference in scores for each level. Japanese junior top level was 0.72, Japanese national top level was 0.80 and World national top level was 0.74, World Best4 was 0.68. It means that the correlation for Wold class is lower than Japanese class.

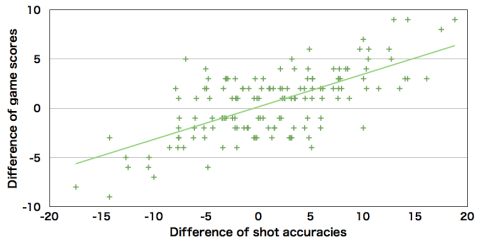


Figure 3: Correlation between difference of shot accuracies vs. difference of game scores for the Sochi Winter Olympic Games.

Figure 3 shows a diagram representing a correlation between difference in shot accuracy, and difference in scores and regression line for 93 newly collected games. In Figure 3 , the X axis shows difference in teams' shot accuracies each game and the Y axis represents the difference in game score.

Figure 3 indicates considerable positive correlation between difference in shot accuracy and difference in scores. Pearson correlation coefficient between the two differences for total data was 0.68. This result was lower than the above mentioned Japanese junior top level. However, teams' shot accuracies was $82.01 \pm 5.80 S.D.$ It was higher than Japanese national top level in Figure 2. In other words, game information of world class teams indicated a very high shot accuracy. And yet the correlation between the two differences was low. These results were similar to those of Masui et al 2016. This means that tactics or planning each end has an impact on game result or difference of game scores[2].

It could be possible that the correlation is negatively influenced by outliers. The more games containing outliers, the lower the correlation. It can be expected that we could expose the process of how tactics or strategies affect game result or difference in game scores by analyzing the games of outliers.

Next, we analyzed two games in which the team of superior shot accuracy lost due to failure in tactics.

Figure 4 and Figure 5 represent graphs showing transition of teams' shot accuracies for every end of each game. The X axis means number of ends and the Y axis shows team shot accuracy.

As shown in Figure 4, game deployment does not indicate the difference in game scores until the middle of the game. While near the end of the game, team A gained multiple scores and won the game. As the rate of shots performed by each team, ratio of *takeout shots* for team A was 64% (51 shots in total of 80 shots) and ratio of *draw shots* was 36% (29 shots in total of 80 shots). Team A performed more takeouts than draws. On the other hand, ratio of *takeout shots* for team B was 51% (41 shots in total of 80 shots) and ratio of *draw shots* was 49% (39 shots in total of 80 shots). Team B performed similar number of *takeout* and *draw shots*. *Takeout shots* reduce the score probability of opponent team because they forced a stone out of the *house*. *Draw shots* raise the score probability of one's own team because they accumulated stones the *house*. In short, as the cause of victory it can be considered that team A took the tactics of risk aversion by performing selected *takeout shots* and accurately taking advantage of missed shots performed by team B. In fact, in third end and ninth end, team A obtained their scores because the situation changed due to missed shot of team B.

As Figure 5 shows team A's draw shot accuracies is 100% from fourth end to eighth end. However, they made some scores only at the fifth end. Also in this game, team B which won the game had the*takeout shots* as 64% (49 shots in total of 76 shots) and the *draw shots* as 36% (27 shots in total of 76 shots). It means that team B performed more *takeouts* than *draws*. In the game information of world class, the teams' shot accuracies exceed 80% and a standard deviation is small. It suggests that one missed shot can have an impact on match situation more than in games of Japanese national top level. Also in this game, it can be considered that tactics of team B was based on purposeful using missed shots of team A.

Therefore, as the cause of victory we can determine that team A took the tactics of risk aversion as their priority. Thus the selected tactics and a contributing shot (or miss) had an impact on game result.

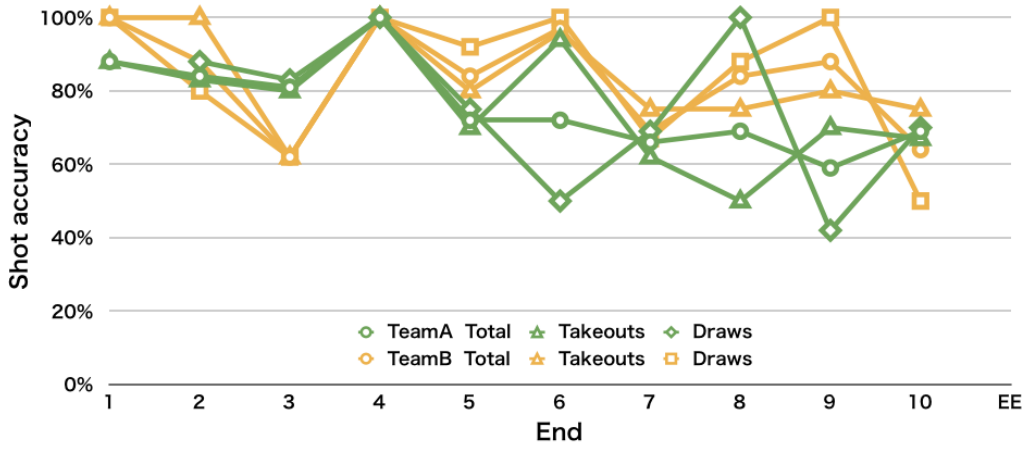
5 CONCLUSION

In this paper, we performed the analysis of game information of a number of curling game matches by using the digital scorebook *iCE* developed by Masui et al. (Masui et al 2016).

The result suggested that the difference of shot accuracies is related to the difference of the game scores. Also, we confirmed that this correlation is lower at the world class. Furthermore, we analyzed the game information of outliers from tactical point of view. It was proven that the selected tactics and a contributing shot (or miss) had an impact on game result.

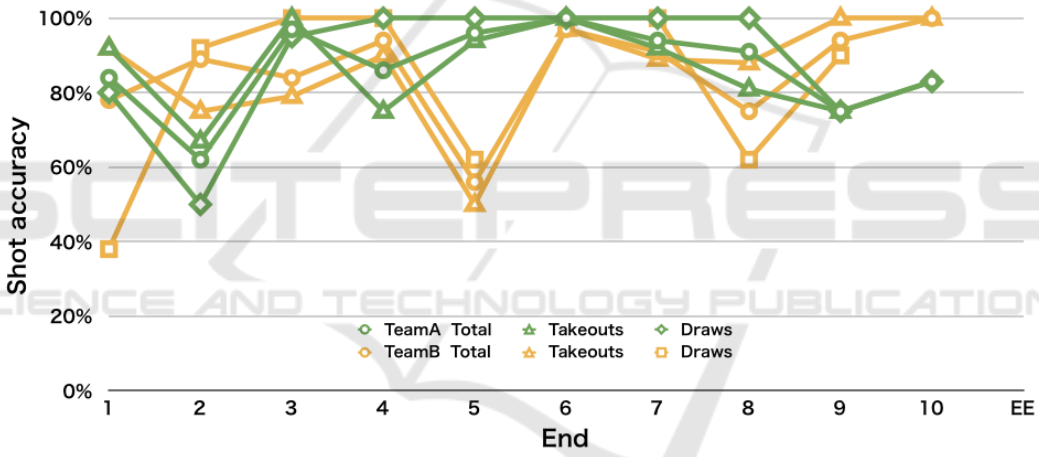
In the near future, we plan to record game information of World national top level and analyze it in detail. In addition, we will specify the process of how the team strategy/tactics influences the game results or the difference of game scores.

[2]For example, intentionally performing a missed shot.



TEAM	1	2	3	4	5	6	7	8	9	10	FINAL
A	1	0	2	0	0	0	1	0	2	1	7
B	0	2	0	0	1	0	0	2	0	0	5

Figure 4: Team's shot accuracies for every ends and transition of game score(1).



TEAM	1	2	3	4	5	6	7	8	9	10	FINAL
A	0	1	0	0	2	0	0	0	0	X	3
B	1	0	0	2	0	0	0	1	2	X	6

Figure 5: Team's shot accuracies for every ends and transition of game score(2).

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