Ice Hockey Player Tracking and Identification System Using Multi-camera video

Gi-Mun Um
Electronics and Telecommunications Research Institute (ETRI)
Daejeon, Republic of Korea
gmum@etri.re.kr

Changeun Lee
Electronics and Telecommunications Research Institute (ETRI)
Daejeon, Republic of Korea
celee@etri.re.kr

Sangjoon Park
Electronics and Telecommunications Research Institute (ETRI)
Daejeon, Republic of Korea
sangjoon@etri.re.kr

Jeongil Seo
Electronics and Telecommunications Research Institute (ETRI)
Daejeon, Republic of Korea
seoji@etri.re.kr

***Abstract*— We present an ice hockey player tracking and identification system based on the videos acquired from multiple camera system. The proposed system reduces tracking errors by global tracking with multi-camera video and player identification using SVM (support vector machine). In the test experiments, the proposed system could achieve the performance of average tracking speed of 16 fps with four cameras, and the average recognition rate as 98.8 %.**

Keywords*— *player tracking, camera video, player identification

I. Introduction

For the best performance of group sports game such as ice hockey, each player's trajectory, velocity, and acceleration can be useful in analyzing the game performance of each player during the game. To do this, we need to track players and get their positions as accurate as possible.

Currently, there are two types of methods that are used to acquire player's positional information especially for sports game analysis. First type is a method that utilizes position sensors such as UWB (Ultra-Wide Band). It measures each player's position by communicating with the tag attached to players. Hockydata's LPM-based hockey track system [1] belongs to this type. This position sensor-based approach can acquire relatively accurate player's position and can easily identify players with tag ID, but its' acquisition speed is relatively slow. The other type is a method that uses video processing techniques. SPORTSLOGiQ [2] and ICEBERG [3]'s player tracking system belong to this category. Video processing-based approach is able to track players more quickly than sensor-based approach. However, this approach has position errors when there are overlapping and occlusion between players. These kinds of errors are mainly because there is no appropriate player identification function to separate overlapped players in the conventional methods. Therefore, we propose an ice hockey player tracking and identification system that utilizes a multi-camera video and a jersey number-based player identification. This paper consists of as follows: following the introduction, the detailed description of the proposed system is given in section II. Next, section III describes test results of the proposed ice hockey player tracking and identification system and finally, we conclude in section IV.

This work was supported by ICT R&D program of MSIP/IITP [2017-0-00543, Development of Precise Positioning Technology for the Enhancement of Pedestrian's Position/Spatial Cognition and Sports Competition Analysis].

II. Proposed ICE HOCKEY PLAYER TRACKING AND Identification SYSTEM

The proposed ice hockey player tracking and identification system using multi-camera video mainly consists of five different modules including player tracking module, camera calibration module, player identification module, event tagging and video segment extraction module, and ROI (Region of Interest) view selection module as shown in Fig. 1. More detailed explanation about each module will be given in the following subsections.

A. Player Tracking

The player tracking module tracks ice hockey players from the images acquired from multi-camera system. In order to reduce tracking errors due to occlusion and overlap between players, multi-camera videos with different viewpoints are used to track players for more robust tracking. Tracking accuracy can be further improved by in a hierarchical procedure, which consists of local player tracking and global tracking. At local tracking stage, ice hockey player region extraction and its position tracking process are performed in each individual camera using a technique in [4]. Then all tracked positions of detected players in each camera are transferred to global tracking module and cross-checked across different camera views. Finally, only valid positions of each player that pass the crosscheck test are recorded to the database and further used for the game performance analysis of each player or team.

B. Camera calibration

Camera calibration module estimates extrinsic and intrinsic camera parameters including focal length, camera position, and camera pose information. In common, the checkerboard pattern with different poses and positions are used to extract feature points and these feature points are used for the camera calibration. However, moving this checkerboard pattern and changing its pose and position is not easy because the size of the checkerboard pattern should be large enough when we capture the scene from the far distance such as ice rink.

Therefore, we instead adopt a new camera calibration technique, which extracts each player's region and its center line obtained from player extraction and tracking information. With the extracted center line of each player, we calculate extrinsic and intrinsic camera parameters without camera calibration pattern. Fig. 2 illustrates the block diagram of the camera calibration algorithm by player's region and its center line extraction.

978-1-7281-2150-5/19/$31.00 ©2019 IEEE

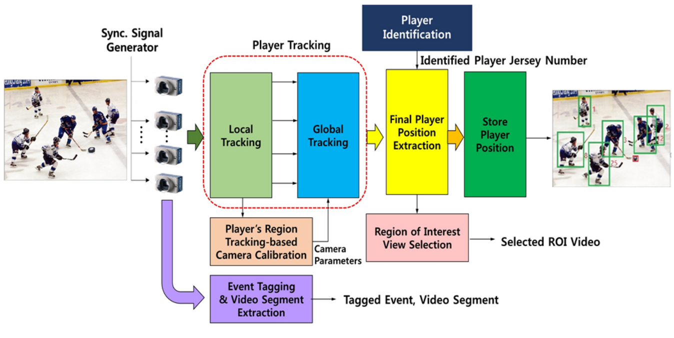


Fig. 1. Proposed multi-camera video based ice hockey player tracking and identification system.

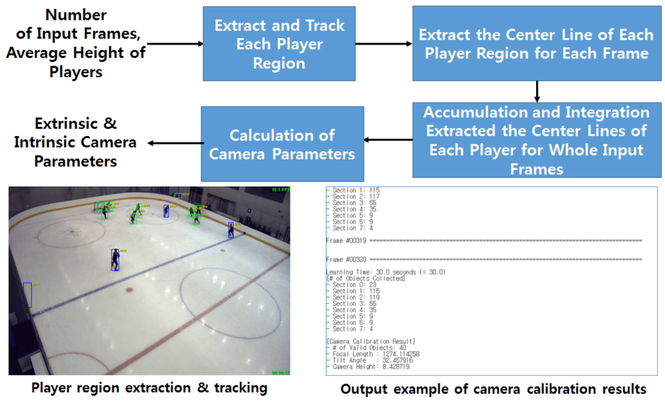


Fig. 2. The block diagram of the camera calibration algorithm by player's region and its center line extraction.

C. Player Identification

Even if we use multi-camera based video tracking, we observed that some players are not detected for a certain period of time and re-detected repeatedly. In this case, that player's ID is re-assigned as a new player to be tracked. Moreover, overlapping two players' ID can be switched each other due to occlusion. These kinds of tracking errors cannot be corrected without knowing all players' correct ID. If we could do this, correct positions of missed or switched players could be recovered. However, most conventional tracking algorithms have no player identification function. Position sensors such as UWB (ultra-wideband system) positioning system or player jersey number recognition techniques could be used for player identification. In this paper, we investigate the feasibility of player identification technique through jersey number recognition before adopting it to the tracking system. As a jersey number recognition algorithm, we test the RGB color model for jersey number region extraction, and SVM (support vector machine) technique [5] for jersey number recognition. We first test the performance of a player jersey number recognition technique for non-close-up video as shown in Fig. 3. Training and test sample images are captured from the tracking cameras or a separate camera. For the team recognition, we first generate a Grab cut [6]-based RGB jersey color model of each team. We also generate a color model of jersey number. With these models, we extract player's jersey region and jersey number region.

Fig. 3. Example of the test images used for the player jersey number recognition

Then, connected contour extraction and filtering is applied to extracted jersey number region for enhancing recognition rates. Then jersey number recognition is performed by using SVM [5]. These processes are illustrated in Fig. 4. The player identification can be done periodically with a fixed time interval such as every few seconds or whenever the operator requests. If the jersey number recognition is successful, the incorrect player's jersey number or ID can be switched to correct one. After correcting the identified player's position, the final position and trajectory of each player could be stored to the database for the analysis of the player performance or the team performance.

D. Event Tagging & Video Segment Extraction

During the game, it is important to analyze player's performance and game results. If a coach selects the category of event located in event tag button, the start time and end time of the selected event are set with a pre-defined time interval according to the button-clicked time. Then, the start time and end time of the tagged event are stored in the database. In addition, the corresponding video segment clip of each tagged event can be replayed at any time. Fig. 5 illustrates an example of GUI (Graphic User Interface) menus for event tagging and video segment extraction.

E. ROI(Region of Interest) view selection

For the performance analysis of ice hockey players and team during the game, team coach often captures the game by panning a video camcorder to the moving direction of players.

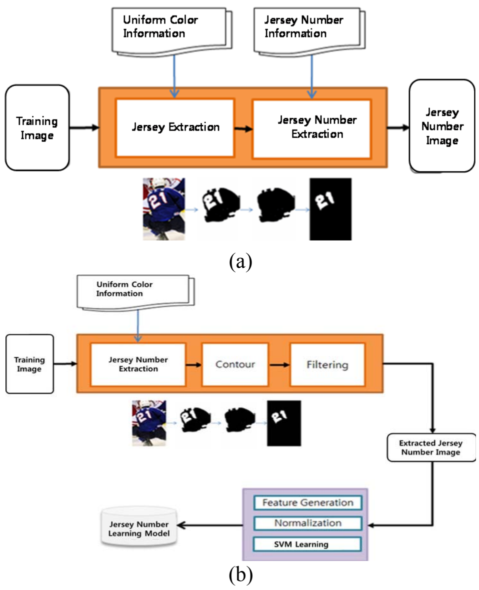


Fig. 4. The block diagram of the adopted player identification process (a) player jersey number region extraction (b) player jersey number recognition.

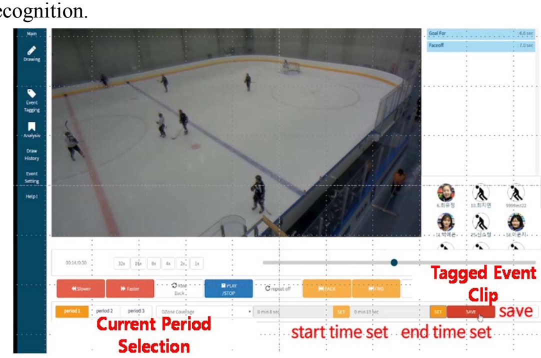


Fig. 5. An example of GUI for event tagging & video segment extraction.

In order to automate this manual job, we propose a ROI (Region of Interest) view selection function based on the tracked position of ice hockey players. The ROI view selection is a function that counts the number of players in each camera view that captures the game, and selects one view that includes maximum number of players among them. With this functionality, team coach can make a highlight video of the game without moving the camcorder manually. In our test-bed system, we used three camera views to cover the whole ice rink as shown in Fig. 6. The field of view of each camera view covers left, center, and right part of ice rink with partial overlaps, respectively.

III. Experimental Test Results

To verify the feasibility of the proposed ice hockey player tracking and identification system, we performed an experimental test at real ice hockey training game. More details are given in following subsections.

A. Test-bed for the experimental test

We first installed the test bed system at the ice rink of the Jincheon National Training Center. Eight cameras for tracking players are installed at the ceiling of ice rink, and three cameras for game event tagging, event segment extraction and ROI view selection are installed at the upper side wall. Another one camera for player identification was also placed on the balcony of locker room located at 4th floor of the ice rink building. The ice hockey player tracking and identification system server is operated in the ice hockey player's locker room. For temporal synchronization of cameras for tracking, an external 5 V trigger signal is applied to each camera. Each camera video is acquired by in-house developed software with Giga-Ethernet frame grabber boards. Acquired videos are encoded with MPEG-4 AVC and stored as mp4 format. The maximum input resolution of each input video is 1,920 by 1,080, and its maximum frame rate is 30fps. For the faster ice hockey player tracking, a player tracking software reduces the image resolution as half of the input video. In addition, multi-thread framework is used to speed up tracking. We assign each thread to track players in each camera. Each ice hockey player's position in each frame is regarded as valid when the tracked positions of the same player from more than two cameras agree with each other. Fig. 7 shows the test-bed system layout installed at the ice rink of the Jincheon National Training Center.

B. Player tracking test

We tested the performance of the proposed player tracking module using 4, 6, and 8 cameras, respectively. At least 4 cameras are used to prevent tracking errors that are caused by overlap and occlusion between players while we cover the whole area of the ice rink. We checked out the changes of tracking speed in unit of fps and player missing or switching rates visually as the number of cameras increases.

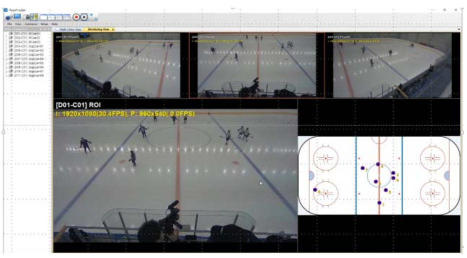
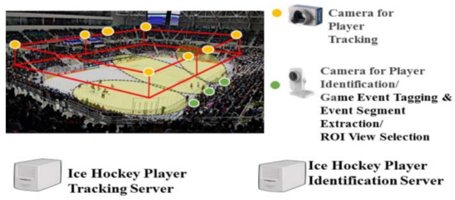


Fig. 6. An example of ROI(Region of Interest) view selection.

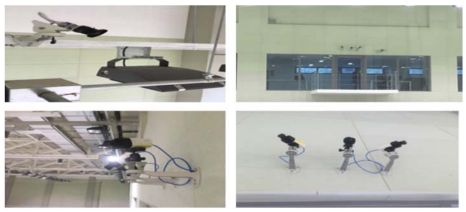
Fig. 8 shows the snapshots of the ice hockey player tracking test when we use 4, 6, and 8 cameras, respectively. The measured average tracking speed for each case is shown in Table 1. We can see that the average tracking speed become slower as the number of cameras used increases. From the results from Table 1, we found that we should decide the number and positions of cameras for tracking by considering the decline in tracking speed compared to the speed of ice hockey players as well as the robustness to the occlusion errors.

C. Player identification test

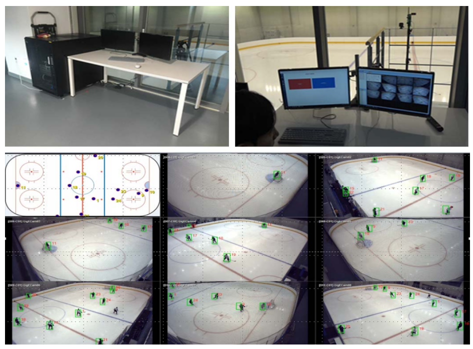
We performed the preliminary experiment for the proposed jersey number extraction and recognition technique with 251 test jersey number images as shown in Fig. 3. Fig. 9 shows typical image changes of the jersey number region. Input images are sharpened and their intensities are increased for the better recognition. Fig. 10 shows the snapshot of the player jersey number extraction and recognition process. Fig. 11 shows the player identification results of the preliminary experiment with 251 test image data. As shown in Fig. 11, we can see that the proposed player identification algorithm worked well even if there are various image changes such as blur, rotation, and distortion. Out of 251 test image data, 248 test jersey number images were recognized correctly and only two severely blurred images and one largely rotated image failed to be recognized correctly. In total, the average jersey number recognition rate was about 98.8 %. With this promising result, we could expect that player identification by player jersey number recognition may contribute to improve player tracking accuracy.



(a)

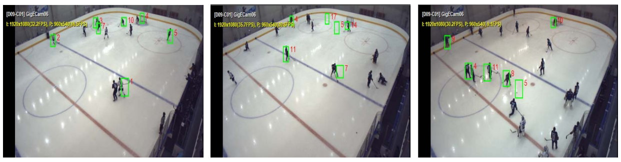


(b)



(c)

Fig. 7. Test-bed system for the experimental test of the proposed ice hockey player tracking and identification system installed at the ice rink of the Jincheon National Training Center (a) camera layout (b) installed cameras (c) servers and an example of ice hockey player tracking test.



(a) (b) (c)

Fig. 8. Snapshots of the ice hockey player tracking speed test when we use 4, 6, and 8 cameras for tracking (a) 4 cameras (b) 6 cameras (c) 8 cameras.

TABLE I. THE AVERAGE TRACKING SPEED WITH DIFFERENT NUMBER OF CAMERAS USED FOR TRACKING

The Number of Cameras used for Tracking Ice Hockey Players	The Average Tracking Speed(fps)
4	16.6
5	10.6
6	9.1

Fig. 9. Typical image changes of the jersey number region.

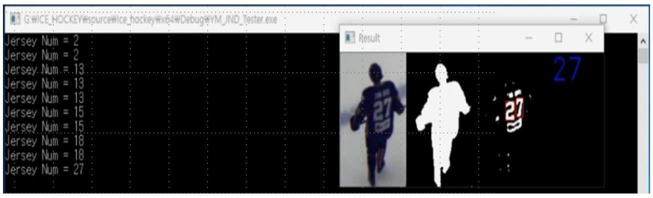


Fig. 10. The snapshot of the player jersey number extraction and recognition process.

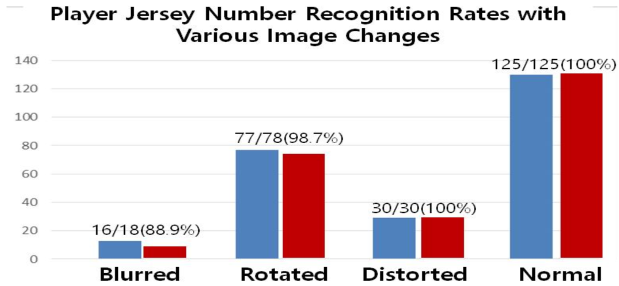


Fig. 11. The player identification results for 251 test data with different image changes in the preliminary experiment.

IV. CONCLUSION

We have presented a novel video-based ice hockey player tracking and identification system by using multi-camera video. The proposed system reduces tracking errors by using multi-camera-based hierarchical global tracking. Moreover, we confirmed the feasibility of player identification through the jersey number recognition for the tracking error correction. As future works, we plan to enhance the player identification module by using artificial neural network [7] and produce a unified system by integrating with player tracking module.

REFERENCES

[1] https://www.inmotiotec.com/en/technology/inmotio-system

[2] https://sportlogiq.com/en/

[3] https://www.iceberg.hockey/technology

[4] Y. Kim and K.Cho, "Robust multi-object tracking to acquire object oriented videos in indoor sports," Proceedins of ICTC2016, pp.104-1107.

[5] C. Verleysen, and C. D. Vleeschower, "Recognition of sports players'numbers using fast-color segmenation," Proceedings of SPIE 8305:23, 2012.

[6] D. Khattab, H. M. Ebied, A. S. Hussein, and M. F. Tolba, "Color image segmentation based on different color space models using automatic GrabCut," The Scientific World Journal, vol. 2014, pp.1-10.

[7] I. Türkyılmaz and K. Kaçan, "License plate recognition system using artificial neural networks," ETRI Journal, vol.39, no.2, April 2017, pp.163-172.