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AN AUTO-SCORING BILLIARDS SYSTEM

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Abstract:

Recently, since the opening climate of Taiwanese society, the billiards becomes more and more popular. Besides, the sport association and interested persons also encouraged not only the activity but also setup the club among many colleges that further push billiards fast developing. Meanwhile, because many males and females billiards won the expecting good prizes at international races, the billiards has achieved unheard-of climate. In tradition, billiards has the artificial scoring which not only lack of automatic method to record the each ball which been hit into pocket when player win the game but also without the backend analysis system. Therefore, our system combined the RFID, TCP/IP and IR with Internet sense capability to make use of UML Object-based analysis technology. We implemented the client/server model using C++ programming language to design the 9.Ball@RFID system having the characteristics of instant record (Tag sensor), analysis (database), broadcast (Webcam) which should be used to train athletic for recording the analysis of batting steps but also for the billiards race to setup the live scoring. After the system testing, the reliability has an acceptable level at 96.47% for identification the billiards' balls. It shall be a good model of billiards table manufacturers for future commercialization because that the prototype developing cost is low.

Keywords:

Billiard; Sport; Auto-scoring; RFID; Sensor

1. Introduction

This study applies information technology in combination with RFID, TCP / IP and IR sensing element, Internet, and SQL database to record automatically information related to the training shots in billiards game and composes necessary analysis software to improve the efficiency, quality and correctness of traditional manual scoring so that plenty and complete analysis data can be provided to players, coaches, commentators, journalists, billiards columnists, spectators, and even the remote users during the cue sports process.

2. Related research

The billiards scoring in the old days all handled manually by hand. It was not only inefficient but also difficult to display the game standing in real time through the internet platform during the match period. For example: the design of microprocessor billiards scoring row in [3]Loulo(2005) uses high brightness LED to display scores, green hand pressed buttons "+,-" to add or subtract points directly for pocketed balls, red hand pressed buttons "+,-" to add or subtract points directly for fouls, and orange hand pressed button to calculate the total and reset at the end. There were also cases to use mechanical tracks and manually move magnetic indicators to record the billiards scoring. Some used computer scoring system in order to reflect the match standing in real time. One example was the score board display on Internet (www.wpa-tour.com/scoreboardA.asp) designed by WPA (World Pool Billiard Association). It not only displays the matching data for players but also helps the postmortem data analysis. Other than these instances, currently, only [2](Ko, 2006) applies multiple technologies such as image processing, pattern recognition and expert systems etc. to develop an automatic scoring system for billiards tables. It transmits images to computers and analyzes the positions and information for each ball through the use of image processing technology to replace referees in the billiards matching so that the course of the match can be analyzed and scored by computers. However, even if the scoring is done by computer systems, the majority of the data such as the number and the position of pocketed balls etc. are still manually entered by hand like in the WPA case mentioned before. Further data processing follows afterward. The problems for this kind of scoring systems include: (1) traditional manual scoring can not satisfy the need of real time sharing of information. (2) computer scoring systems which require manual input will not save on labor costs. (3) scoring system can only record player's data and data that can be analyzed in depth is lacking. (4) traditional scoring

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system can not deliver the tournament data and game standing information to the remote users far away through Internet. If the Internet spectators can also check on the previous matching records for players at any time during the course of the match, it will enhance the visibility of cue sports.

3. Implementation

This system embeds RFID Tags into billiards balls (simulated with Ping Pong balls) and installs RFID Readers in the six pockets on the billiards table respectively. A passage made of half a translucent Paute bottle is installed on top of the RFID reader so that the pocketed balls can be read. Also, infra-red breaker components are installed on the six standing locations around the billiards table as shown in Fig. 1 to sense the player's striking position and send the signals to server through TCP/IP network. The player's shot is then transmitted live to client side applications through Internet. Therefore, it can utilize effectively the RFID functions such as identification, broadcast, and real-time analysis of the database (computing) etc. and at the same time, address the shortcomings of traditional manual scoring and record the billiards shot's process in a smoother manner. The main hardware devices: RFID Readers, Model TW-986R are installed in the locations of the six pockets, Site 1 - Site 6. TW-9900 will collect all the data read by the readers and send them to the D-Link DSS-164 on the Internet. Infra-red breakers, Model number MR-220 set, are installed between pockets to sense the player's standing position. The ON/OFF signal of the Infra-red breaker and the signals from the pressure sensors (self-made short circuit spring metal) are transmitted to the D-Link DSS-164 on the Internet through seven IP-Sensors, 9201 when players fetch cuesticks. These data are also sent to the backend servers for the purpose of system determination. The details of these hardware devices are documented in Appendix. The usage scenario displays the proportion between the self-made table, player, and all the hardware devices and the real table. After assembling the aforementioned hardware devices such as sensors etc., the system will transmit information via Internet and display monitoring screens such as the pocketed balls situation at each pocket, where the players stand, and the score standing of both sides etc. on the server. These screens will display on the client side as well.

To verify the aforementioned functions, unit tests, integration tests, and system tests are performed on this system. The pressure sensors to detect the lifting of a cue stick by a player are included in the tests and found to be 100% reliable. The infra-red breakers to detect the player's location among the six different standing positions next to the table are also tested and found to reach 100% reliability.

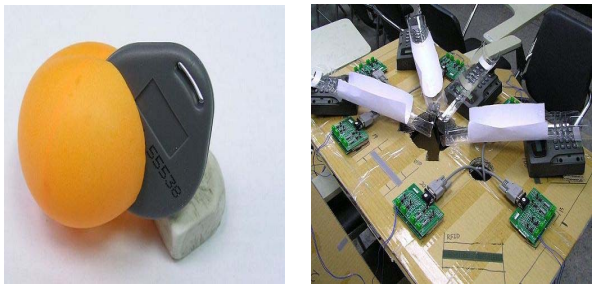

Figure1. RFID and the design of balls and pocket

Furthermore, in order to analyze the reliability for the instantaneous detection of the pocketed balls at the moment when they are sunk into pockets, test plans are designed to shoot each ball into each pocket at different angles respectively from different standing positions. The angle for the path of the ball to sink into the pocket is fixed at 30 degree angle and the striking force onto the cue ball is set at an average force of 200g±10. The distance between the object ball and the pocket is set on the edge of a semi-circular fan with a 25 cm radius. Every angle for each pocket is tested respectively for 50 times of sinking a ball repeatedly and the RFID detection results are recorded. The average detection is calculated to reach 96.47%. It shows that the RFID detection of this system meets the reliability requirement.

Despite all these reliability tests, it is still not sufficient to prove that the system is indeed practical and feasible. Therefore, professional personnel such as players, coaches, and journalists etc. are invited to test the system to obtain their insight, feedbacks, and suggestions to this system. They are compiled in Table1.

Table 1. Feedbacks from players, coaches, and journalists

	Insight / Feedback and suggestion
Player	The system will not impact greatly the original way of shooting the ball Tag will affect the balance of the ball rolling Should consider using actual tables for development and testing. Will experiment with Tag on the surface of a real ball for next phase
Coach	It is capable of scoring immediately and can spare the inconvenience of using paper and pen. It is better suited for the use of a usual practicing facility. Pocketed ball detection up to 100% It is not capable of recording the mood of players.
Journalist	The scoring system can complement human errors while using paper and pen. The output should use the WPA display screen as a reference.

Comparing this system to the image processing method in [2] (Ko, 2006), there is no need to use a complex image processing mathematical model for computation. Therefore, it will save the CPU computation resource and also, because of the unique identification property of RFID Tag, the predicament of misidentifying ball's image can be effectively avoided. Furthermore, it can broadcast the live shots and the scores through Internet by the effective use of TCP/IP, which is also unmatched by the other system. The comparison is shown in Table 2.

Table 2. The comparison between this system and a system using the image processing method

	Computation method	Detection	Speed
9.Ball @RFID	Tag comparison (general computation)	Tag antenna	Reader instantaneous detection
[2] Ko (2006)	Image recognition algorithm	CCD lens imaging	Mathematical software calculation

4. System assessment and review

The system takes RFID components and applies them for the automatically scoring in the cue sports. Data and information is collected through the use of electronic equipments. The examples for these data are : the single-game, "the cumulative number of pocketed balls" for each player, "The average time for shots", "the visit frequency", "play time", "the number of misses", "the number of clean table shots", "the cumulative number of scratches," "The number of pocketed balls for the opening break shot,"" The numbers of those pocketed balls for the opening break shot, "" the number of shots with more than two pocketed balls," "the number of pocketed shots when behind," "the number of pocketed balls for each pocket," "the shortest time for a winning game," "The duration of the complete match" etc. It can easily record all the shots data to a database to achieve the objective of data preservation. It can convey the status of the billiards game in real time through the text messages on the scoreboard. It can provide the related statistics timely to players or the staffs on the scene. It even has an interesting yet informative scoreboard interface to ease the atmosphere. The assessment for the relevant benefit provided by the prototype under limited funding and manpower is described as follows:

It is an innovative concept with low development cost for the prototype (6 sets of RFID Reader cost about $1370, Tag costs about $1.43, a set of IP sensors is about $85.71 and 6 sets of infrared breaker cost about $68.57. Therefore, the total hardware cost is lower than $1571.43. ($1 equal to NTD 35) There are 4 development personnel and the duration of the development is about 1 year). Therefore, it should possess high commercial value when it is transferred to the real billiards table in the future; Record all the shots data effectively for immediate database analysis; Complement the cable broadcast and provide an internet channel; All the related technologies are all matured. There is no need to spend a long time to do the conversion between platforms.

The usual scoring methods use hand recording method to record the results of each player. This system is capable of detecting automatically the player's standing position, the number of shots, and the numbers of balls pocketed etc. through RFID, TCP/IP, and IR sensors etc. It is also capable of recording these data to database automatically for further analysis and displaying the shots data on the remote client computers immediately. If all the historical training records for a player are available in a database, it is possible to find out whether there are some hidden factors which will impact the performance of the player during training or competition through further analysis. However, in order to understand the operational benefits of the system in more precision, tests and verifications to the related hardware and software are performed. The examples are: the stability of the scoreboard software, the stability of the surface of the billiard table, the stability of the striking point on the ball, the stability of the bouncing shot from the side walls, pressure sensors, IR sensors, the reliability of the detection

capability of the RFID readers (including different between ball sinking angles and standing positions). After statistical analysis on the related data, the reliability of the system is concluded as reaching the acceptable level of a prototype system. In subsequent studies, other than improving all the points mentioned above, we also plan to enhance the detection rate of the pocketed balls sinking into pockets. The current system merely embeds a passive tag inside a ball. When the ball rolls over a RFID Reader, the embedded tag may be out of the wireless scanning range and result in a read failure due to the fact that the speed and the position of the ball can not be fixed. In the future, semi-active or active tags should be experimented or move the RFID Reader to the bottom of the pocket instead of on the side of the pocket to enhance the wireless detection range of the balls. These are all the directions for consideration.

However, if it is desirable to develop the system further toward a commercial system, it is necessary to improve the hardware environment in addition to the task of matching the software analysis functions with the user's requirements better when the system is further developed in the future. The points in discussion are: structural design of Billiards table, RFID, and TCP/IP, bonding of RFID tag and the ball body without impacting the balance of the rolling of the ball, setting up webcams without interfering the striking of balls, hiding of wirings to reduce the visual obstacles etc. At the same time, after the implementation of the system, we accepted interviews(05/22/2008 14:30-16:00) by Mr. C.W. Jao, project manager of Business Incubation Center of Feng Chia University, and Dung-Ching Lin, manager of Kao Fa Wood Factory Co., Ltd (www.poolcues.com.tw), one of the few surviving domestic factories dedicated to the manufacturing of the cue stick industry. Kao Fa had a history of providing funding to aid "cue sports technology" through Industrial Development Bureau Ministry of Economic Affairs and also supported many domestic cue sports athletes. They expressed the opinion that the concept of the system was excellent and matched the research objectives well. However, there is still room for further research and development on the recording of the track of balls. The reason is after the player makes a shot, there are often occasions that result in balls sunk into pockets indirectly, for example, one cushion and two cushion etc. in the jargons of cue sports. Also, shots of masse, side spin, back spin, and kiss etc. are probably all required video recording first then are subsequently identified through image processing. The analysis of player's shot habits, ability to solve difficult shots, set up traps for opponent, and the difficulty of shots etc. can not be accomplished by using RFID on the ball body only; the solutions for these difficult problems require subsequent investigation. Furthermore, based on the Interview advices given by Mr. Miles Liao, Patent Attorney of Taiwan Technology Patent and Trade Mark Office, the system has proved that it is possible to collect and record information concerning hitting a ball into a particular pocket through RFID devices and store them into database for further analysis. Therefore, Mr. Liao also recommended us to apply for new applications or patents in order to protect the rights of the inventors (the Ministry of Economic Affairs Intellectual Property Bureau case number: 097109603).

5. Conclusions and future work

Through the use of simple electronic elements, TCP/IP module, IR sensors, pressure sensors, and the Reader and Tag of the RFID etc., application software can detect the trigger time of all the events occurred in a cue sports match and achieve the function of automatic scoring. It can also record all the relevant data through the application software and store them into a SQL database so that persons who are interested in the cue sports can do real time analysis in the backend such as: (1)Players and coaches: players and coaches can record and analyze the relevant statistics or ratio of pocketed shots and pockets through the use of the system (9.Ball@RFID). Not only can they understand their own problems of making shots, they can also understand the historical competition records or habits of making shots of their opponents. (2) Commentators, journalists, and cue sports columnists: Commentators, journalists, and cue sports columnists can record the complete process of the cue sports event, write columns, understand the striker's characteristics, perform a complete and details illustration, and provide fans with accurate information of the match standing through the use of this system. (3)Spectators: The system can display, in a real time fashion, the most up-to-date information to the spectators. It can even allow spectators to examine the past competition statistical records of the players at any time during the competition to enhance the visibility of the cue sports. In summary, currently, all the RFID domestic success stories are using the products of foreign manufacturers; domestic manufacturers who do their own R & D on related hardware and software are still quite rare. We know from assessing the benefits of the system that it is imperative for us to reduce the system development cost and develop new technologies so that we can sustain the future application of RFID technology research and development. In additional to develop the front-end Reader equipments and micro Tag materials etc. through Electrical and Electronic Technology, it is more important to combine them with all kinds of innovative business applications such as the application to

health care in [1](Wang, 2007) and more easy and rapid tools for system development. By doing so, it is possible to truly expand the RFID application level and attract more talented people and private enterprises into the research and development of RFID products so that RFID can become a flourishing industry.

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