23

A Wireless Sensor Network for Field Hockey Performance Analysis

Shamala Subramaniam, Mohammed Ahmed Almoqry, Sangeetha Thavamani, Roger Canda, Mohamed Othman and Zuriati Zulkarnain
University Putra Malaysia
Malaysia

1. Introduction

The tracking of human movement has indeed become a central issue in acquiring optimized and strategy based solutions in various domains of applications. The utilization of technology in the enhancement of tracking players in a team sport is an evident applications which should utilize sensors. The game of field hockey is a sports requiring two main cohesive human movement. The first being individual and the second representing the group dynamics. Groups in the game of field hockey represents micro-human network formation and of the entire eleven players on the field. Among the pertinent sports technology utilized by field hockey teams is based on video visualization and the capturing of the player movement (Lu, 2007). In order to gain a clear understanding of the situation on the ground, it is becoming vital to observe from close range, using remote sensing devices placed in the area of interest. However, there are only a few movement tracking systems available today, and most of these systems are wired which tend to pose constraints in terms of movement (Wang, 2005). There are also a constrained number of wireless sensor available today to track human movements. Among the developed solutions is a wearable wireless sensor network to capture human movement (Wang, 2005). The system was tested on dance performance. In this research the advantages were for the development of the wearable sensor which permitted mobility through wireless. However, the research did not address the significance of coordinated interactions from a network sensor configuration and reconfiguration. The ability of applied WSN onto military applications are amplified by the possibility to provide intelligent cohesive network reconfiguration. In this research, the coordinated wireless sensor was not based on individual or pair human tracking system but is enhanced by the ability to focus on optimization based on multiple network configurations. Large networks of wireless sensors and actuators pose a number of problems that are not present in smaller networks of wired devices. Although current generation devices, such as the Mica motes, have limited processors (motes have an 8-bit, 7 MHz processor) and memory (motes have 4 KB of RAM and 512 KB of Flash), it is expected that in a few years these limitations will be much less severe. In distinguishing our research, test application encompassing human tracking in correlation to Game Analysis is proposed. The game constitutes of equipment control which is highly dependent on the human movement. This is distinctly different from those in deployment (Michael, 2005). The major

Source: Convergence and Hybrid Information Technologies, Book edited by: Marius Crisan,
ISBN 978-953-307-068-1, pp. 426, March 2010, INTECH, Croatia, downloaded from SCIYO.COM

findings were made in Real-time game analysis systems. The researcher developed the Football Interaction and Process Model (FIPM) and a software system that can acquire, interpret, and analyze this model. The FIPM system acquires models of player skills, infer action-selection criteria, and determine player and team strengths and weaknesses. However, the research has several evident limitations. Firstly, the research has confined correlation between the sensor networks to a specific problem domain involving mobility of nodes with a ratio of 1 device: n nodes. the utilization of equipment based nodes where a highly interdependency exist between : (i) equipment and node and (ii) node – to – node is clearly not addressed. Thus, requiring newly developed software which is able to provide a high distinction between the indicidual tracking to the real-time analysis of sensor data from human tracking with dependency of multiple sensory components (i.e. field hockey-sensor on player, stick and ball). The potential of hybrid systems encompassing communication technologies (i.e. WSN and adhoc) and human tracking remains immense. This research proposes the cohesive development of WSN field hockey strategy system and a Discrete Event Simulator. The focus is based on utilizing an Indoor Sensor System to correlate with the field hockey strategy board. The remainder of the Chapter is organized as follows. Section 2 reviews the existing physical magnetic board which provides static positioning. Section 3 discusses the Cricket Indoor Location system utilized to acquire the location of the mobile nodes. Section 4 discusses the developed Wireless Sensor based Field Hockey Strategy System. Section 5 deliberates the detail of the Grid formation both physically and in simulation. Section 6, discusses the results acquired from the experiments. Section 7 provides the conclusion and some pertinent discussion on the future research.

2. Magnetic board static positioning

The magnetic board for visualizing the multiple options of a strategy is generally used to illustrate the various strategies. The magnetic board for field hockey comprises of a magnetic board and several bi-colored magnets used to represent the players and the opponents. Figure 1 show the magnetic board being used for a discussion session with players. The movement explanation is of relation to certain set-pieces (i.e. pre-determined strategies). Figure 2 illustrates a practice drill which is conducted. The lines denote the expected movement of the players and the ball movement. The strategy board is also utilized in addition to video analysis such as the SportsCode (Sebastian et al, 2006) to capture and relate to the players the required movements. These pre-dominant software can be complemented for the purpose of strategy configuration and capitalizing group dynamics. Field hockey coaches utilize these magnetic boards during team video analysis sessions and even during half-time of matches. In view of the ability of the magnetic board to be enhanced to an intelligent board, the integration of sensor were used in our research. The magnetic strategy board allows single dimensional movement. In addition the board is unable to provide real-time computation on the deviation of the intended pre-determined movement as opposed to the multiple options which relate to a movement.

The objective of this research is to materialize a dynamic strategic board whereby movements of magnetic node will be able to provide the location of the opponent and the respective restricted or obstacle zones of the area. This paper contains the details of the location detection hardware (i.e. Cricket Indoor Location System) and the Virtual dynamic magnetic board. At present the integration of the system is being rapidly researched.

Fig. 1. Magnetic Board Utilized for Strategic Movement

Fig. 2. Pre-determined Set-Pieces conducted during training sessions.

3. Cricket indoor location system

The location detection system which was used for this project is the Crossbow Cricket Indoor Location System. The main motivation of utilizing the Cricket Indoor Location System is the scalabilty and the independence from pre-defined coordinate pre-requisite. Thus, the Mica2 sensors (i.e. Beacons) can be positioned on any field hockey Grid. The specifications of the system used is shown in Table 1.

Items and Descriptions
8 Cricket Mote Processors Radio Boards with Ultrasound (433 MHz)
1 MIB510CA Programming and Serial Interface Board

Table 1. Specifications of the Cricket Indoor Location System used in the research.

The project was able to be done using an Indoor location system as opposed to the Outdoor location system due to the fact that the developed system is intended to be strategy software for the team management to utilize either prior or during training. The sensors are attached as representation of the magnetic nodes and the area defined in the application varies in the terms of the set-piece intended. The beacons were attached to mobile stands to enable flexibility of movements. Figure 3 shows the attached sensors (i.e. beacons) on the experiment set-up.

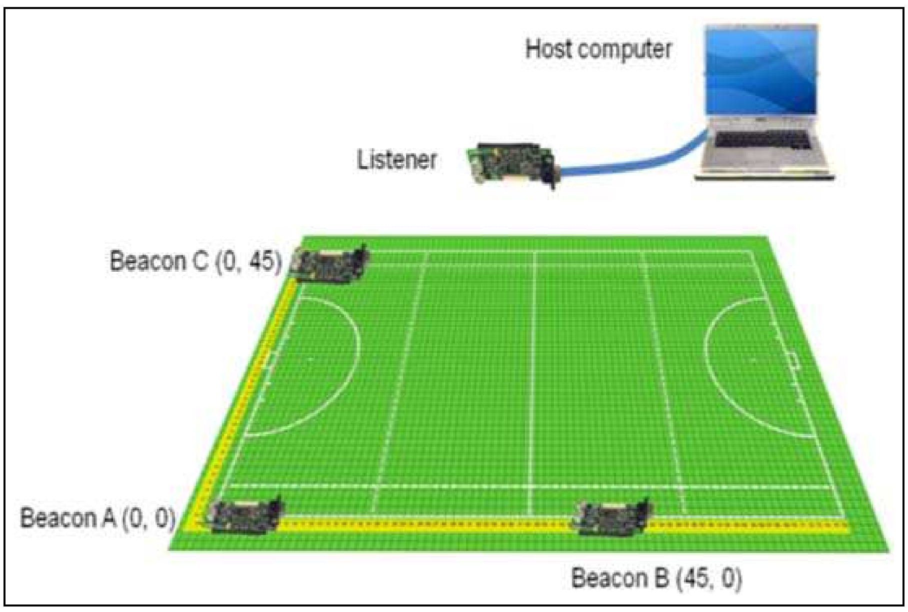


Fig. 3. Wireless Sensors (Beacons) attached Field Hockey Grid.

4. Wireless sensor based field Hockey strategy system (WiHoc Ver 1.0)

Concurrently to the deployment of the Cricket Indoor location system, the development of the application for the simulation of the field hockey was developed. The application is intended to visualize the movements and intended team coordination. The system enables the user to input the data movement using the simulation. In response the data movement is produced for the coach to analyze. The simulator enables the coach to input basic benchmarks, which subsequently is displayed on the screen.

5. Grid and DES development

The WiHoc Ver.1.0 was developed using the Cricket/Mica2 mote (Shamala et al, 2008). An important feature of the Cricket system is the ability to be independent of any pre-defined coordinate systems. Thus, advocating the importance of the beacon positions with the stipulated area of research. In this research, a Grid was formulated specifically for the field hockey pitch specification. The formulation of the Grid must precede the subsequent algorithms due to the localization requirements. The magnetic board for visualizing the multiple options of a strategy is used to illustrate the various strategies and set-piece movements. The magnetic board for field hockey comprises of a magnetic board and several bi-colored magnets used to represent the players and the opponents.

Figure 5, illustrates the attributes and respective measurement metrics of a field hockey pitch. The measurements represent the actual physical measurements of the field of play scaled on a per meter to centimeter.

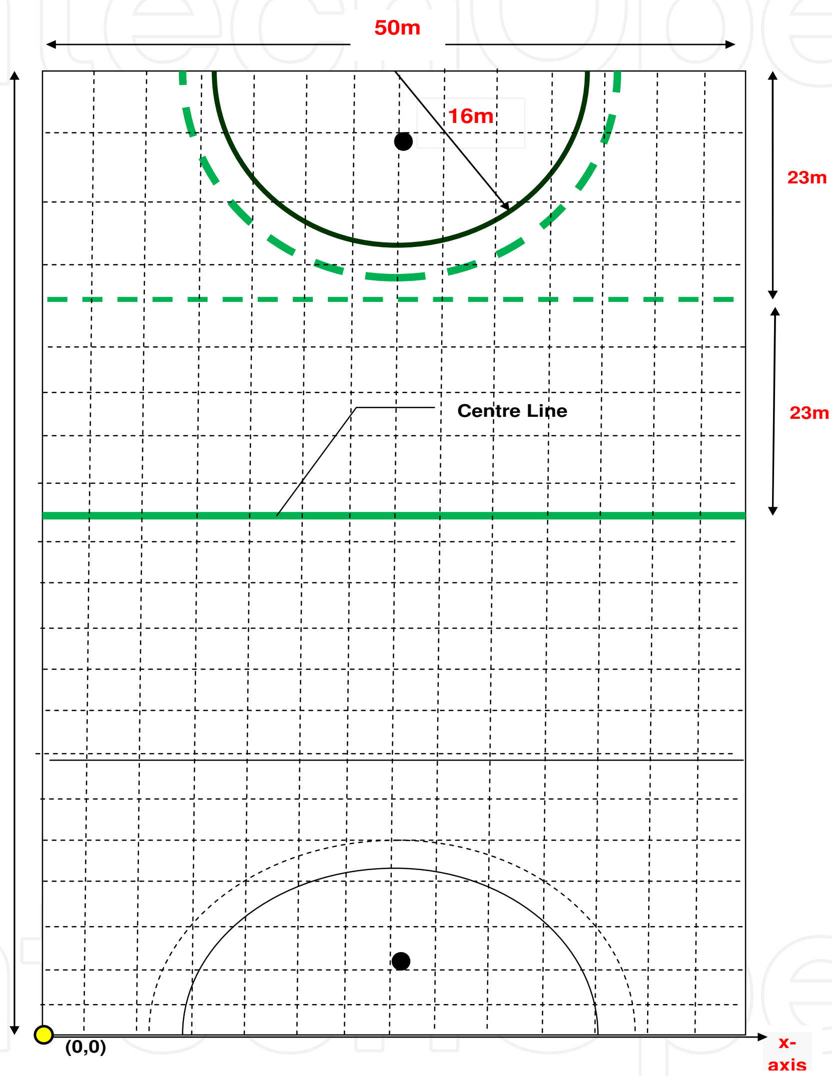


Fig. 5. Grid (x,y) formulation for field hockey

In this project, the magnetic components have been replaced with Mica2 sensors. Thus, enabling real-time data to be computed as opposed to passive and static visualization of the conventional strategy board. Each point represents an x and y coordinate respectively. The Mica2 beacon position were placed at the coordinates of (0,0), (45,0) and (0,45). The listener adopts mobility based on the user's discretion. For the purpose of performance analysis of the developed system, a Zig-Zag mobility movement was utilized on the physical Grid.

The WiHoc mobility benchmark utilized is shown in Figure 6. The listener is connected to the main software to compute the distances generated by the beacons Radio Frequency (RF) and Ultrasound (US) data collection. The computed coordinates are subsequently visualized by the software. In the WiHoc Ver. 1.0, the data is computed and further analyzed utilizing a spreadsheet software. The main analysis was the mapping of the field hockey strategy board to the Cricket/Mica2 system catering it's respective perquisites.

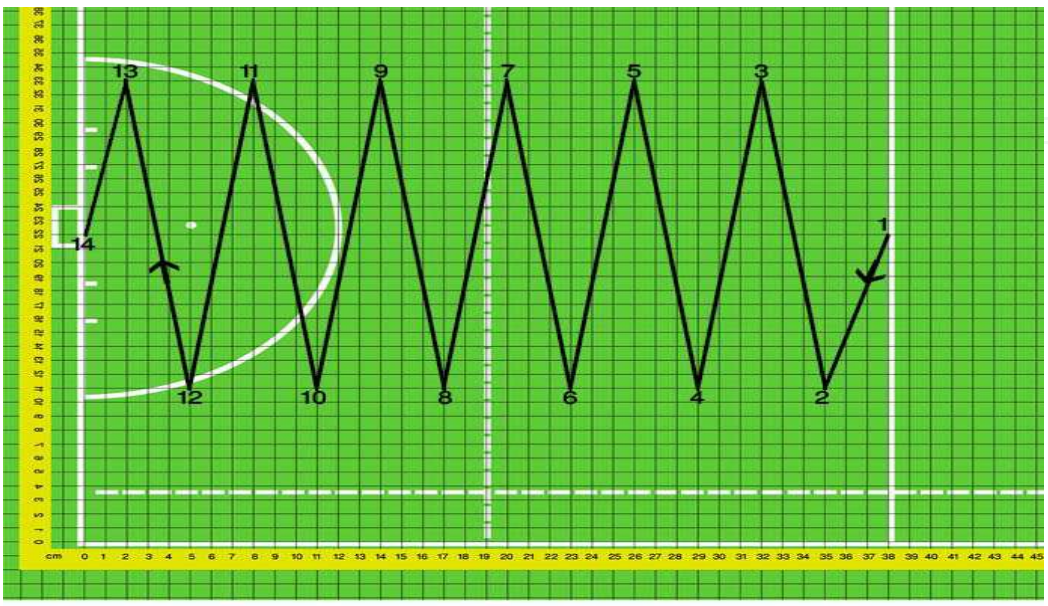


Fig. 6. WiHoc Ver.1.0 Model Development – Mobility Benchmark

Parallel to the deployment of the WiHoc Ver.1.0 testbed, a complementary performance analysis tool using simulation as the underlying platform was developed. The Discrete Event Simulator (DES) developed the following:

i. Event Definition – each event was derived based on the occurrences which causes statistical changes to the system. Four main events have been identified for this project as follows:
   a. Beacon Transmit RF
      Event to generate RF for the beacon
   b. Beacon Transmit US
      Event to generate US for the beacon
   c. Listener Receive RF
      Event to process receiving of RF by the listener
   d. Listener Receive US
      Event to process receiving of US by the listener
ii. Scheduler – the scheduling of the events. The main controller of the simulation is the scheduler and no direct control of the function deployment by the user
iii. The computation of the location utilizing the Geometrical formulation
iv. The performance measurement utilizing accuracy metrics and generation of graphs

The developed DES was derived based on the model in Figure 6. The simulation was developed using Microsoft Visual C++. The performance analysis used three beacons and one listener. The computation of the location was achieved using the signals transmitted by each beacon. Each beacon transmits a RF and an US signal simultaneously. RF carries location data, while US is a narrow pulse. The listener measures the time gap between the receipt of the RF and US signals. A time gap of x ms corresponds to a distance of x distance

from beacon. The simulation used fixed location coordinates of beacons and US rate at 344 ms and RF at 3x 10^8 ms. The computational requirements are deliberated in Table 2.
The Cricket units were set up in a grid coordinate, with beacons 1-3 at positions (0,0), (45, 0), (0, 45). An algorithm was deployed and tested for precision and accuracy. This algorithm solves the equations of 3 distances values received by the listener from 3 beacons. The distance between current position and target were derived using the following Equation (1) which was adopted from (Nissanka, 2005). The performance metrics used to validate the developed simulator and the ability to simulate the WiHoc Ver.1.0 is distance. Each beacon is directly involved in estimating the listener position. The information consists of space id, preset coordination (x,y) of the respective beacon.

$$\text{Distance} = \text{velocity} \times \text{time} \quad (1)$$

Where velocity is the speed of the sound and time is the difference between the time of arrival for the RF and US signals with the following adopted:

a. Y-axis — the y coordinates of the listener in the cricket field grid. The cricket field grid is 100m x 50m. The y value ranges from 0 to 50 m.
b. X-axis — the x coordinates of the listener in the cricket field grid. The cricket field grid is 100m x 50m. The x value ranges from 0 to 92 m.

Hardware	Specification
Processor	Intel Core(TM)2 Duo T300@2.00GHz
Memory	1 GB
Hard Disk	160 GB HDD with 40 GB for Linux partition
Display	Intel Graphic Media Accelerator 900
Monitor	14.1” WXGA Crystal Bright LCD
Operating System	Microsoft Office XP
Programming Language	Visual C++ version 6

Table 2. Computation Requirements of the developed DES

The DES functional operations encompasses of :

a. Initialization – function to provide starting values for control parameters, performance metrics and simulation paraemeters
b. Scheduler – the events are activated based on chronological activation for each of the events
c. The simulation was repeated for 42 cycles to acquire the coordinates
d. Generation of results via performance metrics of distance and coordinate generation

Extensive experiments were conducted to validate the developed simulator and it’s ability to replicate the WiHoc Ver.1.0 system.

6. Results and discussions

A scenario of Zigzag movement was utilized to represent the listener’s movements in the test-bed. The movement correlates to the gradual movement of two players moving a ball towards the goal scoring area. The reading from the Cricket 2.0 software for 14 positions while moving was captured. Table 3 displays the utilized movement of the listener, the first column (x, y) value is the initial coordinate of the listener and the subsequent movements. These reading were recorded on the actual physical strategy board.

Movement ID	Listener position	Movement ID	Listener position
1	(38.00, 22.00)	8	(17.00, 11.00)
2	(35.00, 11.00)	9	(14.00, 33.00)
3	(32.00, 33.00)	10	(11.00, 11.00)
4	(29.00, 11.00)	11	(8.00, 33.00)
5	(26.00, 33.00)	12	(5.00, 11.00)
6	(23.00, 11.00)	13	(2.00, 33.00)
7	(20.00, 33.00)	14	(0.00, 22.00)

Table 3. Listener Movement

The results obtained from the Cricket System are shown in Figure 7. The analysis of the results displays deviations between the physical readings and the Cricket software. This is due to the interference and the accuracy of the RF and US data collection. In order to validate the acquired results, the deviation and it's respective impact of the field hockey strategy was analyzed. The maximum x-axis deviation was 0.86 while the minimum was 0.18. For the y-axis deviation, the maximum was 2.62 and the minimum was 0.2. Mapping these deviations to the physical Grid, enabled a distinct observation on the results. The acquired results were indeed acceptable for the purpose of game analysis as the locations on the grid scaled to per unit factor of the physical location have a neglible effect and is displayed in Table 4.

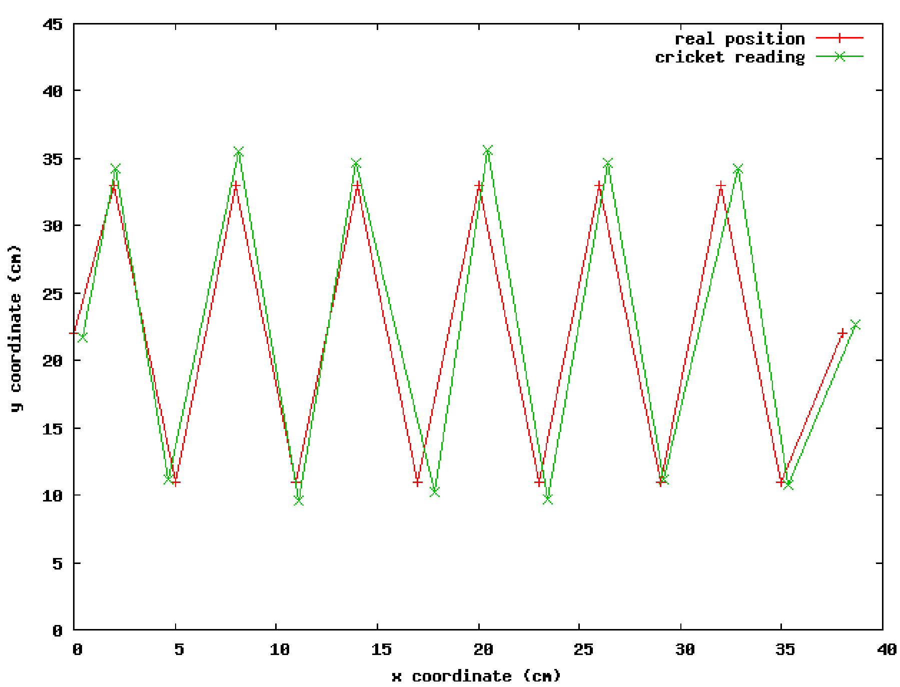


Fig. 7. True positioning error, comparing distance measured to distance expected

# of motion	Actual position	WiHoc Correlation	# of motion	Actual position	WiHoc Correlation
1	(38.00, 22.00)	(38.65, 22.69)	8	(17.00, 11.00)	(17.86, 10.26)
2	(35.00, 11.00)	(35.36, 10.80)	9	(14.00, 33.00)	(13.98, 34.63)
3	(32.00, 33.00)	(32.84, 34.29)	10	(11.00, 11.00)	(11.09, 9.58)
4	(29.00, 11.00)	(29.18, 11.17)	11	(8.00, 33.00)	(8.13, 35.53)
5	(26.00, 33.00)	(26.41, 34.67)	12	(5.00, 11.00)	(4.64, 11.13)
6	(23.00, 11.00)	(23.46, 9.74)	13	(2.00, 33.00)	(2.03, 34.22)
7	(20.00, 33.00)	(20.48, 35.62)	14	(0.00, 22.00)	(0.46, 21.71)

Table 4. Test-bed results, listener position reading from Cricket software

To validate the developed DES, the results in Figure 8 were generated and analyzed. The results validate the developed Simulator and it's respective ability to serve as a performance analysis tool complementary to the real physical experiemental testbed. The deviations acquired were between 5-8% difference. Many factors attributed towards the neglible difference including room temperature.

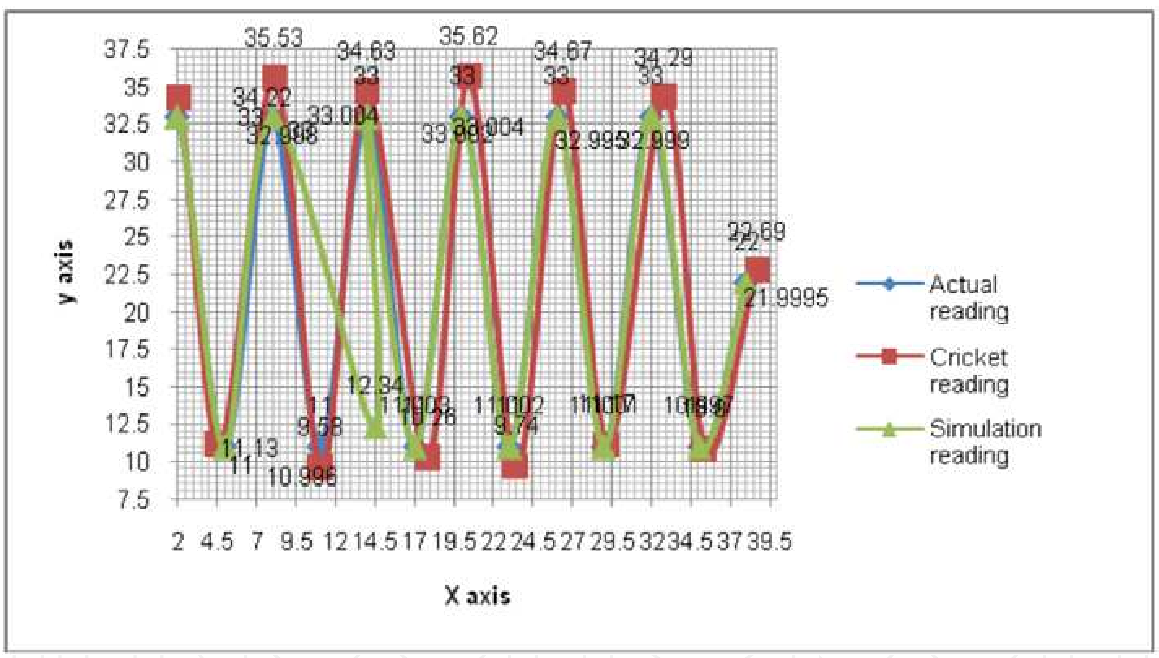


Fig. 8. True positioning error, comparing distance measured to distance expected of the developed DES

7. Conclusions and future work

This project has enabled the wireless sensor indoor location system to embark into an enhanced platform of sports in general and field hockey in particular. The Cricket Indoor Location System developed by Crossbow and MIT has the ability to detect the movement of players but at a scale most applicable to a strategy board. This project is in the process of rapid development to integrate the location detected by the sensors with an application enabling a layman to utilize it to its highest potential. The project is in the process of incorporating an application which translates the Cricket location coordinates into an application and integrating obstacle zonal computation intended to provide a wide spectrum of strategies for the use of the team management. In addition, this research has developed a Grid enhancement to the Wireless Hockey Strategy System to acquire the computation ability for Game Analysis. The derived coordinates, will enable the team personnel of field hockey to analyze the multitudes of analysis from even a singular movement. However, in the testbed further analysis such as localization algorithms and power consumptions are literally impossible to be done. Thus, a discrete event simulator was developed specifically to replicate the WiHoc Ver.1.0. The simulator was able to utilize the distance factor of the Cricket /Mica2 motes acquired from the physics formula of distance being equivalent to velocity multiplied by time. The simulator has indeed enabled a wide spectrum of experiments and analysis to enhance the performance of the development WiHoc Ver.1.0. The research is ongoing to produce WiHoc Ver.2.0 with a GUI based software to integrate Artificial Intelligence and expand the developed DES for a various mobility models and modules for power consumption.

8. Acknowledgment

This project is funded by the ScienceFund of the Ministry of Science, Technology and Innovation of Malaysia under the grant number 01-01-04-SF0224 and by University Putra Malaysia.

9. References

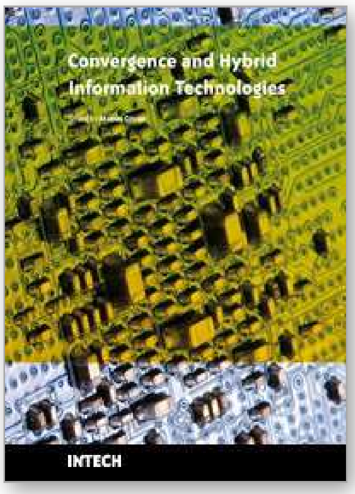
Lu. W.L. (2007). Tracking and Recognizing Actions of Multiple Hockey Players using the Boosted Particle Filter, *Master's Thesis*, The University of British Columbia.

Wang. Y. (2005). Human Movement tracking using a wearable sensor network, *Thesis*. IOWA State University.

Shamala.S, Soon.L, Tareq, R, Canda. R, Maher,A and Yahya.A. (2008). Wireless Sensor Based Field Hockey Strategy System, *In Proc. International Conference on Convergence and Hybrid Information Technology* (ICCIT'08), Busan, Korea.

Nissanka B.P. (2005). The Cricket Indoor Location System, *PhD Thesis*. Massachusetts Institute of Technology.

Michael B., Bernhard K. and Martin L. (2005). Computerized Real-Time Analysis of Football Games, *IEEE Pervasive Computing*, vol. 4, no. 3, pp. 33-39, July-Sept. 2005, doi:10.1109/MPRV.2005.53



Convergence and Hybrid Information Technologies
Edited by Marius Crisan

ISBN 978-953-307-068-1
Hard cover, 426 pages
Publisher InTech
Published online 01, March, 2010
Published in print edition March, 2010

Starting a journey on the new path of converging information technologies is the aim of the present book. Extended on 27 chapters, the book provides the reader with some leading-edge research results regarding algorithms and information models, software frameworks, multimedia, information security, communication networks, and applications. Information technologies are only at the dawn of a massive transformation and adaptation to the complex demands of the new upcoming information society. It is not possible to achieve a thorough view of the field in one book. Nonetheless, the editor hopes that the book can at least offer the first step into the convergence domain of information technologies, and the reader will find it instructive and stimulating.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821