Overview of Data Mining Technique for Data Gathered using Wireless Sensor Network

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Abstract: In today's era, Wireless Sensor Networks (WSN) is used in various application areas like home, health, agriculture to name a few. WSN comprises of large number of tiny sensor nodes. The main tasks of a node in WSN is to sense data, process and communicate with other nodes. When used in large numbers, large amount of data is generated during its lifetime operation. This data at times needs to be transferred from a node to the base station. Transferring a large scale of data consumes more energy because of long transmission time. Wireless Sensor Network's data is concern with different data classes and different data formats. Data needs to be converted in different formats for generating information which results in data mining. Recent innovation in data mining technique receives attention in extracting knowledge from data gathered using WSN.

In this paper, we have given an overview of wireless sensor network and data mining. We have also listed some WSN applications and looked at how various techniques of data mining have been used in WSN applications. Finally, we have recommended a data mining technique that can be used on monitoring data collected through WSN.

Keywords- *Wireless Sensor Network, Data Mining, Classification, Cluster Analysis, Association Rule.*

I. INTRODUCTION

A rapid development in technology used in networked systems today involves large number of small and low-power wireless devices. Wireless Sensor Networks (WSNs) are widely used for monitoring physical happening of the environment. The data gathered using WSN is bulky, heterogeneous and distributed. Massive data gathering needs an appropriate technique to convert it into productive information. Usually, such problems need some amount of data mining.

Data mining is the process of analyzing data from different perspectives and summarizing it into useful information. Continuous innovations in computer processing power, disk storage, and statistical tools are dramatically increasing the accuracy of analysis while driving down the cost. Various data mining techniques are available which can be used in an application for generation of knowledge based data.

The paper is divided into five sections, section II describes wireless sensor network and its applications, section III discusses data mining and its applications, section IV introduces with various techniques of data mining, section V describes some of the related work, section VI gives the proposed solution for performing data analysis with sample data set of a application of WSN, followed by conclusion in section VII.

II. WIRELESS SENSOR NETWORK

Wireless Sensor Network (WSN) technology enables design and implementation of stimulating applications that can be used in several industrial, environmental, societal and economical challenges [52]. This leads to the constant growth of WSN. The growing interest among the people can be largely credited to new applications enabled by large-scale networks of small devices

capable of retrieving information from the physical environment, performing simple processing on the extracted data and transmitting it to remote locations. Wireless sensor nodes consist of a sensor interface, microcontroller, memory and battery units clubbed together with a radio module [8]. Hence, wireless sensor nodes are able to carry out distributed sensing and data processing, and to share the collected data using radio communications [24] [23] [38].

Sensor networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar, which are able to monitor a wide variety of conditions like temperature, humidity, vehicular movement, lightning condition, pressure, noise levels, speed, direction and the presence or absence of certain objects. Mainly, a sensor node has three main components: sensing, processing and communication [10] [64] [1] [62] [23].

Researchers have categorized the applications into domains like military, environment, health, home and other commercial areas. We have not described each of these areas in detail here. Readers may go through the references provided in the section for details.

Researchers in [20][36][27] discusses the applications used for industrial control and monitoring. Some applications of home automation and consumer electronics are discussed in [58][15][16][14], some military and security applications are discussed in [41][61] [45]. Applications related to asset tracking and supply chain management are discussed in [49] [9]. In [63][30][12][37][28][22] the applications used in agricultural and weather monitoring are discussed. Finally in [29][51][26][2] some applications of health monitoring in WSN are also discussed.

III. DATA MINING

Data mining refers to extracting or "mining" knowledge from large amounts of data [31]. The data is explored and analysis is done to generate meaningful patterns. It is used to take improved decisions in future. Data Mining is also defined as a collection of techniques for efficient automated discovery of previous unknown, valid, novel, useful and understandable patterns in large databases. The patterns must be actionable so that they may be used in an enterprise's decision making process [13][19].

A typical data mining process is likely to follow mentioned steps:

1. Requirement analysis
2. Data selection and collection
3. Cleaning and preparing data
4. Data mining exploration and validation
5. Implementing, evaluating and monitoring
6. Results visualization

Data mining can be applicable to any kind of information repository. This may include relational databases, data warehouses, transactional databases, flats files, World Wide Web, object-oriented and object-relational databases and specific application oriented databases also [31].

Data mining has been applied successfully from many years. The diverse application sets may vary from business to science and from medical to sports. Some of the application areas where data mining is used are discussed below [31][55][7] [11][33][40][53].

A. Data Mining in Health Care

As technology is booming in today's world, the location is not the boundary for a researcher or doctor to diagnose a disease of patients. The data is not limited to only bulky data like doctor's notes but it is also necessary to use text mining to broaden the scope of what data mining can do

in health care. The data mining is also to be done on images, for example, MRI reports of a patient [33][42].

B. Data Mining Shopping in

Data mining technique can also be used in Market Basket Analysis (MBA). When the customer wants to buy some products then this technique helps us finding the associations between different items that the customer shops at the same time. This technique is used for promotion of the business technique. In this way the retailers identifies the customer's intension (buying the goods in different pattern) [60][6][5].

C. Data Mining in Education

In education system, data mining can be used as a bridge for the education aspirants. The use of different patterns and associations that can be generated using educational data can be used in improving decision making process in higher education. This may be helpful in processes like reducing the total educational cost, increase in student's pass ratio, increase in student's retention rate, increase in student's success and many more. This can also prove the quality of education [4][50][44]

D. Data Mining in Finance or Banking

In today's era, banking sector provides services like banking, credit, investment, insurance, etc. This service is given in large segment and thus will result in large quantity of data. Here, data mining can be used for analysis and view of loan payments, creation of new policies for their customer, detection of detection of money laundering and other financial crimes and future decisions based on past data [18][56][43].

E. Data Mining in Retail Industry and E-commerce

The retail industry collect huge amount of data on sales, customer shopping history, goods transportation, consumption and service records and so on. Many companies also have web sites where customers can make purchase online. As a result, retail data provide a rich source for data mining.

The integration of e-commerce and data mining significantly improve the results and guide the users in generating knowledge and making correct business decisions. The data mining can be done on data collected on sales; customer shopping history, goods transported, service records, etc. It helps in discovering customer shopping patterns and trends, improvement in quality of customer service, better customer satisfaction, increase in goods consumption ratio, effective goods transportation, reducing the cost of business and many more [43][59].

F. Data Mining in Sports

Data mining is not only used for business or science applications but can also be used in sports. Huge number of games is played in today's era. Each day some competition, national or international is scheduled, where a huge number of data is to be maintained.

In the sports world the vast amounts of statistics are collected for each player, team, game, and season. The data is then used to discover the patterns; these patterns are often used to predict the future forecast [54].

G. Data Mining in Telecommunication

Telecommunication industry offers local and long distance telephone services for their customer. They also offer other ample communication services like voice, fax, cellular phone, images, e-mail, web data transmission and other data traffic. This create a great demand for data mining in order to provide help to understand the business involved, identify telecommunication patterns, catch deceptive activities, make better use of resources and improve the quality of service [21].

The above set of applications gives us an idea about the vast utility of data mining.

IV. TECHNIQUES IN DATA MINING

Various data mining techniques and algorithms are available for data analysis. Techniques like Classification, Association Rule, Clustering, Web Mining are used for knowledge discovery from databases [31][65][35][3][32][25]. This section discusses them in brief.

A. Association Rule Mining

Association rule is a rule which entails certain association relationships among a set of objects in database. This type of mining helps the user to take certain decisions like customer shopping habits, catalogue design and cross marketing. Applications other then market basket analysis are marketing, customer segmentation, medicine, electronic commerce, bioinformatics and finance. Association rule algorithms should generate rules with confidence values less than 1. However the number of possible Association rules for a given dataset is generally very large and a high proportion of the rules are usually of little (if any) value. Different types of association rules are mentioned herewith: multilevel association rules, multidimensional association rules, and quantitative association rules

B. Classification

Classification is a vital and most commonly used data mining technique that has its origins in machine learning. Classification is the separation of objects into classes. Classification is appropriate when the user wants to classify each item in a set of data into one of predefined set of classes or groups with the sample data available. Classification is used in applications like fraud detection, credit risk applications and also helps researchers in machine learning, pattern recognition and statistics.

And one of the most widely used classification technique is the decision tree. The decision tree technique is widely used because it generates easily understandable rules for classifying data. The classification algorithms use pre-classified examples to determine the set of parameters required for proper bifurcation. The algorithm then encodes these parameters into a model called a classifier. Few classification techniques are decision tree induction, bayesian classification, neural networks, support vector machines (SVM), and classification based on associations.

C. Cluster Analysis

Clustering is the process of grouping the data into classes or clusters. The objects within a cluster have high similarity in comparison to one another but are very dissimilar to objects in other clusters. When the data is collected, the main aim of cluster analysis is to find classes or clusters that are very different from one another. This technique is comparatively costly as compared to other techniques of data mining. One of the most commonly used algorithm is k-means algorithm for partition method. Some of the cluster analysis techniques are partitioning methods, hierarchical methods, density-based methods, grid-based methods, model-based methods, constraint-based clustering.

D. Prediction

Prediction technique is used when the user wants to find out the relationship between the independent variables as well as the relationship between the dependent and independent variables. Regression technique is commonly used for prediction. The independent variables are already known and response variables are to be predicted. This situation arises in real-world like predicting the stock values, sales volumes or any product failure.

For example, we want to predict profit for the company. We can consider sales as an independent variable and profit as a dependent variable. Then based on historical sales and profit data, we can assume or estimate the profit. Different types of regression methods used for prediction are linear regression, multivariate linear regression, nonlinear regression, multivariate nonlinear Regression.

E. Web Data Mining

The Web data mining is used to discover patterns from the Web. The Web is an immense and dynamic collection of pages that includes countless hyperlinks, huge volumes of access and usage information like text, animation, images and sound. It provides a rich data mining source.

The web mining may be used in various approaches like mining web search-engine data, analyzing the web's link structures, classification of web documents automatically, mining web page semantic structures and page contents and mining web dynamics.

1) Related Work

Different data mining techniques has been used in various field of WSN. Some of the data mining techniques used in WSN are as follows.

Mohamed Watfa et. al. in [48] discussed a new data aggregation technique for data of wireless sensor network. They suggested an EEIA approach which consists of providing a new distributed algorithm for query processing in wireless sensor networks. The algorithm is an optimized energy efficient distributed algorithm with respect to all the sensor's resource constraints. The main aim was the reduction in power consumption through reducing the number of query related messages in the whole network.

K. K. Loo et. al. in [34] proposed Interval-List-Based (ILB) online mining algorithm Lossy Counting, a simple but effective algorithm for counting approximately the set of frequent item sets from a stream of transactions. They compared this algorithm with an application of Lossy Counting (LC) using weighted transformation method.

Milica Knezevie et. al. in [47] gave an overview of selected algorithms for mining in Wireless Sensor Networks and discussed benefits of integration of agent systems and data mining algorithms. They proposed classification of the existing distributed data mining algorithms for WSNs and possible integration of agent systems with each class of algorithms.

Kushboo Sharma et al. in [39] proposed a Nearest Neighbor Classification technique to classify the Wireless Sensor Network data for high classification accuracy and classification efficiency. This technique can be used in many real time applications.

Xu Cheng et al. in [65] suggested a hierarchical distributed classification approach which local classifiers are built by individual sensors and merged along with the routing path. The classifiers are combined with pseudo and local data. The main aim for developing this classification was to build high classification accuracy with low storage and communication overhead. They address the critical issue of heterogeneous data distribution among the sensors.

S. Bandyopadhyay et al. in [57] describe the technique for clustering distributed data in sensor networks environment. They propose the technique based on the principal of K-means algorithm. Experimental result demonstrates the effectiveness of the K-Means clustering algorithm for the case when the full data is uniformly and non-uniformly distributed over the nodes.

M. Halatchev et al. in [46] proposed new technique called WARM (Window Association Rule Mining). In Wireless Sensor Network significant amount of data send from sensor to processing points which may be corrupted or lost WARM deal with this type of problem. They also present the performance studies comparing WARM with existing technique.

2) Recommended Technique of Data Mining For Wireless Sensor Network

As mentioned previously, there are numerous applications of wireless sensor networks. Each field/application gathers some data, analyzes the data and takes corrective actions based on the

analysis done. In each application, data is gathered and mining is required on that data to take decisions.

Association rule mining and classification are two important techniques used for data mining. An approach known as Associative Classifier is an integration of association rule mining and classification into a single system. Association rule mining is used to discover descriptive knowledge from the database and classification focuses on building a classification model for categorizing the new data. The main aim of association rule mining is to find all the possible rules in the database that satisfy minimum support and minimum confidence constraints. Here, the target of association rule is not predetermined. In classification model, the target is predetermined, ie. class.

Associative classifier can be constructed in three stages.

- **Stage 1**: Identify the event associations for the frequency of occurrences is significant.
- **Stage 2:** Generation of class association rules(CARs) from the association patterns
- **Stage 3:** Build a classifier based on CARs and put them into appropriate class.

The main advantage of associative classifier is that it is easily understood by humans and has greater flexibility in handling unstructured data.

Let us take two applications of WSN i. e weather monitoring and animal health monitoring. The real time data of weather monitoring is given in Table 1.

Table 1 contains traces of data collected every one hour on 31st March 2012. We have shown the interval of 2 hours. The sensors measure latitude and longitude of the location in GMT, time, date, solar radiation, soil temperature, dry bulb temperature (temperature of air measured by a thermometer freely exposed in air but shielded from radiation and moisture), digitally controlled potentiometer (DCP) for temperature measuring, the speed and the direction of the wind, humidity, rain fall and the sun shine in the area.

Similar to the data shown in Table 1, the animal health monitoring system may have parameters like date, time, heartbeat, blood pressure, temperature, humidity, water ph level, dust level.

As per the single point interface for data analysis of the data gathered using WSN [17], assume that the two users are sending their application data for data analysis. One user is sending the data of weather monitoring system as shown in Table 1 and the other user is sending the data of animal health monitoring system. For data analysis using

Table 1
Weather Monitoring Data of Anand District, Gujrat

Latitude	Longitude	Time (IST)	Solar Radiation	Soil Temp1	Dry Bulb Temp	DCP Housing Temp	Wind Speed	Wind Direction	Humidity	Rain Fall	Sun Shine
22.56667	72.93278	00.30	0	29.3	24.7	12	0.1	11.2	46	0	10.48
22.56667	72.93278	02.30	0	27.8	21.2	11.9	0	359.2	64	0	10.48
22.56667	72.93278	04.30	0	26.2	24.5	12	2	325	43	0	10.24
22.56667	72.93278	06.30	10	25.3	20.3	11.8	0	359.2	69	0	00.00
22.56667	72.93278	08.30	284	26.7	26.4	12.8	1.2	350	40	0	01.12
22.56667	72.93278	10.30	828	34.3	32	12.7	1	37.1	28	0	03.12
22.56667	72.93278	12.30	812	40.2	34.3	12.7	0.9	73.8	25	0	05.12
22.56667	72.93278	14.30	862	43.4	35.8	12.7	0.9	57.2	20	0	07.12
22.56667	72.93278	16.30	590	43.8	36.2	12.8	1.1	12.2	18	0	09.12
22.56667	72.93278	18.30	80	40.1	33.9	12.3	1.6	318.2	20	0	10.36
22.56667	72.93278	20.30	0	35.1	28.6	12.1	0	329.9	31	0	10.36
22.56667	72.93278	22.30	0	31.8	25.9	12	0	359.2	41	0	10.36

association classifier method we need to incorporate the above three stages as mentioned:

1. Access the data and identify the patterns (character or numeric data). Assume that we are using the dataset given in Table 1.
2. Identify the parameter to be used for classification. Here, we assume it to be 'temperature'.
3. Observe that the parameter 'temperature' belongs to both the dataset. i. e weather monitoring system as well animal health monitoring system.
4. Now, to correctly classify if the data belongs to weather application or animal monitoring application, we need to check other attributes which are in association with 'temperature'.
5. A simple rule can be designed here which states that if the other associated attributes are wind direction, wind speed, humidity and rainfall. then we classify that the data belongs to the weather dataset. While, if the other associated attributes turn out to be blood pressure, heart beat and water ph. level. then it can be classified that the data belongs to animal monitoring dataset.

V. CONCLUSION

Huge data set is generated from various applications of wireless sensor network. The data needs to be converted in different formats for generating information and thus data mining is needed. This paper recommends the appropriate data mining method that could be used in WSN. The step 5 mentioned in above process requires a generalized classifier to be built along with the rule set. In our future work, we would generate an algorithm and a classifier which would mine this data depending upon the CARs and would place them in appropriate class.

REFERENCES

[1] Al-Sakib Khan Pathan, Choong Seon Hong, Hyung, "Smartening the Environment using Wireless Sensor Networks in a Country," *ICACT*, 2006, pp. 705-710, ISBN 89-5519-129-4.

[2] Ashraf Darwish, Aboul Ella Hassanien, "Wearable and Implantable Wireless Sensor Network Solutions for Healthcare Monitoring," *Sensors*, 2011, Vol. 11, pp. 5561-5595, ISSN 1424-8220.

[3] Bharati M. Ramageri, "Data Mining Techniques and Applications," *Indian Journal of Computer Science and Engineering*, Vol. 1, Issue: 4, pp. 301-305, ISSN: 0976-5166.

[4] Brijesh Kumar Baradwaj, Saurabh Pal, Mining Educational Data to Analyze Students Performance," *International Journal of Advanced Computer Science and Applications*, 2011, Vol. 2, Issue: 6, pp. 63-69, ISSN: 2156-5570.

[5] Chad Cumby, Andrew Fano, Rayid Ghani, Marko Krema, "Predicting Customer Shopping Lists from PointofSale Purchase Data," *Proceedings of the tenth ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2004, pp. 402-409, ISBN: 1-58113-888-1.

[6] Charles Dennis, David Marsland and Tony Cockett, "Data Mining for Shopping Centres –Customer Knowledge-Management Framework," *Journal of Knowledge Management*, 2001, Vol. 5, Issue: 4, pp. 368-374, ISSN: 1367-3270.

[7] Charly Kleissner, "Data Mining for the Enterprise," *Proceedings of the Thirty-First Hawaii International Conference on System Sciences*, 1998, Vol. 7, pp. 295-304, ISBN: 0-8186-8255-8.

[8] Chris Townsend, Steven Arms, "Wireless Sensor Networks: Principles and Applications," *Sensor Technology Handbook*, 2005, pp. 575-589, ISBN: 978-0-7506-7729-5.

[9] Christof Rohrig, Sarah Spieker, "Tracking of Transport Vehicles for Warehouse Management," *Intelligent Robotics and Systems, 2008, IEEE, International Conference on Computing and Processing*, 2008, pp. 3260-3265, ISBN: 978-1-4244-2057-5.

[10] D. Estrin, R. Govindan, J. Heidemann and S. Kumar, "Next century challenges: scalable coordination in sensor networks," *Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking*, 1999, pp. 263-270, ISBN: 1-58113-142-9.

[11] D. Jensen, J. Neville, "Data Mining in Social Networks," *Dynamic Social Network Modeling and Analysis: Proceedings of the National Academy of Sciences Symposium on Dynamic Social Network Analysis*, 2002.

[12] D. D. Chaudhary, S. P. Nayse, L. M. Waghmare, "Application of Wireless Sensor Networks for GreenHouse Parameter Control in Precision Agriculture," *International Journal of Wireless &*

Mobile Networks (IJWMN), 2011, Vol. 1, Issue. 1, pp. 140-149, ISSN: 2093-5374.

[13] Daniel T. Larose, *"Discovering Knowledge in Data: An Introduction to Data Mining"*, Wiley Interscience, A John Wiley & Sons, Inc. , Publications, 2005, ISBN 0-471-66657-2.

[14] Debraj De, Shaojie Tang, Wen-Zhan Song, Cook, Sajal Das, *"ActiS en: Activity-aware Sensor Network in Smart Environments"*, NSF NetSE program, 2011, pp. 1-29.

[15] Dipak Surie, Olivier Laguionie, Thomas Pederson, "Wireless Sensor Networking of Everyday Objects in a Smart Home Environment," *ISSNIP, IEEE*, 2008, Vol. 8, pp. 188-194, ISBN: 978-1-4244-2957-8.

[16] Dipak Surie, Thomas Pederson, Fabien Lagriffoul, Lars-Erik Janlert, and Daniel Sjolie, "Activity Recognition Using an Egocentric Perspective of Everyday Objects," *UIC 2007*, LNCS 4611, Springer, 2007, pp. 246-257, ISSN 1870-9044.

[17] Disha J. Shah, Harshal A. Arolkar, "Single Point Interface for Data Analysis in Wireless Sensor Networks," *International Journal of Computer Applications*, 2012, Vol. 47, Issue: 9, pp. 22-26, ISSN: 0975-8887.

[18] Dongsong Zhang, Lina Zhou, "Discovering Nuggets: Data Mining in Financial Application," I*EEE Transactions on Systems, Man, And Cybernetics - Part C: Applications and Reviews*, 2004, Vol. 34, Issue: 4, pp. 513-522, ISSN: 1094-6977.

[19] G. K. Gupta, *"Introduction to Data Mining with Case Studies"*, PHI Publications, 2006, ISBN 81-203-3053-6.

[20] Gang Zhao, "Wireless Sensor Networks for Industrial Process Monitoring and Control: A Survey," *Macrothink Institute, Network Protocols and Algorithms*, 2011, Vol. 3, Issue:1, pp. 46-63, ISSN: 1943-3581.

[21] Gary M. Weiss, "Data Mining in Telecommunications," *Data Mining and Knowledge Discovery Handbook: A Complete Guide for Practitioners and Researchers*, 2005, pp. 1189-1201.

[22] Guillermo Barrenetxea, Franc¸oisIngelrest, Gunnar Schaefer, and Martin Vetterli, "Wireless Sensor Networks for Environmental Monitoring: The SensorScope Experience," *IEEE, 2008 Internal Zurich Seminar*, 2008, pp. 98-101, ISBN: 978-1-4244-1681-3.

[22] F. Akyildiz, Weilian Su; Sankarasubramaniam, Y.; Cayirci, E, "Wireless sensor networks: a survey," *Communications Magazine, IEEE*, 2002, Vol. 40, 8, pp. 102-114, ISSN: 0163-6804.

[23] Ian F. Akyildiz, TommasoMelodia, Kaushik R. Chowdhury, *"A survey on wireless multimedia sensor networks"*, Elsevier, 2007, pp. 921-960, ISSN: 0020-0190.

[24] Ian H. Witten, Eibe Frank, *Data Mining: machine learning tools and techniques*, Elsevier, 2005, 2nd Edition, ISBN: 0-12-088407-0.

[25] Ijaz M. Khan, NafaaJabeur, Muhammad Zahid Khan, HalaMokhtar, "An Overview of the Impact of Wireless Sensor Networks in Medical Health Care," *ICCIT*, 2012, pp. 576-580.

[26] James Agajo, AlumonaTheophilus, Inyiama H. C. , "Wireless Sensor Networks Application For Industrial Monitoring," *International Journal of Research and Reviews in Computer Science (IJRRCS)*, 2011, Vol. 2, Issue. 4, pp. 1069-1074, ISSN: 2079-2557.

[27] Jane K. Hart, Kirk Martinez, "Environmental Sensor Networks: A revolution in the earth system science?," Elsevier, *Earth-Science Reviews*, 2006, Vol. 78, pp. 177-191, ISSN: 0012-8252.

[28] JeongGil Ko, Chenyang Lu, Mani B. Srivastava, John A. Stankovic, Fellow IEEE, Andreas Terzis, and Matt Welsh, "Wireless Sensor Networks for Healthcare," *IEEE*, 2010, Vol. 98, Issue: 11, pp. 1947-1960, ISBN: 978-1-4244-1681-3.

[29] Jeonghwan Hwang, Changsun Shin and Hyun Yoe, "Study on an Agricultural Environment Monitoring Server System using Wireless Sensor Networks," *Sensors*, 2010, Vol. 10, pp. 11189-11211, ISSN 1424-8220.

[30] Jiawei Han, Micheline Kamber, *Data Concepts & Techniques*, M K Publishers, 2006, 2nd Edition, ISBN 13: 978-1-55860-901-3.

[31] Jiawei Han Kevin, Chen-Chuan Chang, "Data Mining for Web Intelligence," *IEEE*, 2002, pp. 54-60.

[32] Jyoti Soni, Ujma Ansari, Dipesh Sharma, Sunita Soni, "Predictive Data Mining for Medical Diagnosis: An Overview of Heart Disease Prediction," *International Journal of Computer Applications*, 2011, Vol. 17, Issue: 8, pp. 43-48, ISSN: 0975 – 8887.

[33] K. K. Loo, Ivy Tong, Ben Kao and David , "Online Algorithms for Mining Inter-Stream Associations From Large Sensor Networks," *Advances in Knowledge Discovery and Data Mining*, 2005, Issue: 3518, pp. 143-149, ISSN: 2229–6662.

[34] Kalyani M Raval, "Data Mining," *International Journal of Advanced Research in Computer Science and Software Engineering*, 2012, Vol. 2, Issue:10, pp. 439-442, ISSN: 2277-128X.

[35] Kamran Khakpour, M. H Shenassa, "Industrial Control using Wireless Sensor Networks," *IEEE*, 2009, February.

[36] Kavi K. Khedo, Rajiv Perseedoss and AvinashMungur, "A Wireless Sensor Network Air Pollution Monitoring Systems," *International Journal of Wireless & Mobile Networks (IJWMN)*, 2010, Vol. 2, Issue. 2, pp. 31-45, ISSN: 2093-5374.

[37] KazemSohraby, Daniel Minoli, TaiebZnati, *Wireless Sensor Networks: Technology, Protocols and Applications*, Wiley Publications, 2007, ISBN: 978-0-471-74300-2.

[38] Khushboo Sharma, Manisha Rajpoot, Lokesh Kumar Sharma, "Nearest Neighbour Classification for Wireless Sensor Network Data," *International Journal of Computer Trends and Technology*, 2011, Vol. 2, Issue: 2, pp. 41-43, ISSN:2231-2803.

[39] Krzysztof J. Cios, G. William Moore, "Uniqueness of medical data mining", *Artificial Intelligence in Medicine*, Elsevier, 2002, pp. 1-24, ISSN: 0933-3657.

[40] Louise Lamont, Mylene Toulgoat, Mathieu Deziel, Glenn Patterson, "Tiered Wireless Sensor Network Architecture for Military Surveillance Applications," *SENSORCOMM 2011 : The Fifth International Conference on Sensor Technologies and Applications*, 2011, pp. 288-294, ISBN: 978-1-61208-144-1.

[41] M. Hemalatha, S. Megala, "Mining in Healthcare: A survey of Immunization," *Journal of Theoretical and Applied Information Technology*, 2011, Vol. 25, Issue: 2, pp. 63-70, ISSN: 1992- 8645.

[42] Madan Lal Bhasin, "Data Mining: A Competitive Tool in the Banking and Retail Industries. " *The Chartered Accountant Journal*, 2006, pp. 588-594.

[43] Marie Bienkowski, Mingyu Feng, Barbara , *"Enhancing Teaching and Learning Through Educational Data Mining and Learning Analytics:An Issue Brief"*, Center for Technology in Learning SRI International, 2012.

[44] Mihail Halatchev, Le Gruenwald, "Estimating Missing Values in Related Sensor Data Streams," *11th International Conference on Management of Data*, 2007, Vol. 4443, pp. 981-987, ISBN: 978-3-540-71702-7.

[45] Milica Knezevic, Nenad Mitic, Zoran Ognjanovic, Veljko Milutinovic, "Agent Based Data Mining in Wireless Sensor Networks : A Survey," *E-Society Journal*, 2011, pp. 91-95.

[46] Mohamed Watfa, William Daher and Hisham Al Azar, "A Sensor Network Data Aggregation Technique," *International Journal of Computer Theory and Engineering*, 2009, Vol. 4, Issue. 1, pp. 19-26, ISSN: 1793-8201.

[47] Mohamed Watfa, William Daher and Hisham Al Azar, "A Sensor Network Data Aggregation Technique," *International Journal of Computer Theory and Engineering*, 2009, Vol. 4, Issue. 1, pp. 19-26, ISSN: 1793-8201.

[48] Mohamed Zied Quertani, Ajith Kumar Parlikad, Duncan Mcfarlane, "Towards an Approach to select an asses information management strategy," *International Journal of Computer Science and Applications*, 2008, Vol. 5, pp. 25-44, ISSN: 0972-9038.

[49] Mohammed M. Abu Tair, Alaa M. El-Halees, "Mining Educational Data to Improve Students' Performance: A Case Study," *International Journal of Information and Communication Technology Research*, 2012, Vol. 2, Issue: 2, pp. 140-146, ISSN 2223-4985.

[50] Moshaddique Al Ameen, Kyung-sup Kwak, "Social Issues in Wireless Sensor Networks with Healthcare Perspective," *The International Arab Journal of Information Technology*, 2011, Vol. 8, Issue. 1, pp. 52-58, ISSN:1683- 3198.

[51] Mr. Hoang DucChinh, Yen Kheng Tan, "Smart Wireless Sensor Networks,", *2010 InTech*, 2010, Issue. 1, ISBN: 978-953-307-261-6.

[52] Neelamadhab Padhya, Pragnyaban Mishra, and Rasmita Panigrahi, "The Survey of Data Mining Applications And Feature Scope," *International Journal of Computer Science, Engineering and Information Technology (IJCSEIT)*, 2012, Vol. 2, Issue:3, pp. 43-58, ISSN : 2231 – 3117.

[53] R. Schumaker, O. Solieman, and H. Chen, "Sports Knowledge Management and Data Mining," *Annual Review of Information Science and Technology (ARIST)*, 2009, Vol. 44.

[54] Rafael S. Parpinelli, Heitor S. Lopes, Alex A. Freitas, "An Ant Colony Based System for Data Mining: Applications to Medical Data," *Genetic and Evolutionary Computation Conference*, 2001, pp. 791-798, ISBN: 1-55860-774-9.

55] Rajanish Dass, "Data Mining in Banking and Finance: A Note for Bankers," *Handbook of Data Mining and Knowledge Discovery*, 2002, PP. 1 -15.

[56] Sanghamitra Bandyopadhyay, Chris Giannella, Ujjwal Maulik, "Clustering Distributed Data Streams in Peer-to-Peer Environments," *ScienceDirect*, 2006, Vol. 176, Issue: 14, pp. 1952-1985, ISSN: 0740-8188.

[57] SatishV. Reve, SonalChoudhri, "Management of Car Parking System Using Wireless Sensor Network," *International Journal of Emerging Technology and Advanced Engineering*, 2012, Vol. 2, Issue. 7, pp. 262-268, ISSN: 2250-2459.

[58] Suhail Ansari, Ron Kohavi, Llew Mason, and Zijian Zheng, "Integrating E-Commerce and Data Mining: Architecture and Challenges," *WEBKDD'2000 workshop: Web Mining for E-Commerce - Challenges and Opportunities*, 2000.

[59] Sven F. Crone, Didier Soopramanien, "Predicting Customer Online Shopping Adoption - an Evaluation of Data Mining and Market Modelling Approaches," *Proceedings of The 2005 International Conference on Data Mining, DMIN 2005*, 2005, pp. 20-23

[60] Tareq Alhmiedat, Anas Abu Taleb, Mohammad Bsoul, "A Study on Threats Detection and Tracking Systems for Military Applications using WSNs," *International Journal of Computer Applications*, 2012, Vol. 40, Issue. 15, pp. 12-19, ISSN: 0975 – 8887.

[61] Th. Arampatzis, J. Lygeros, S. Manesis, "A of Applications of Wireless Sensors and Wireless Sensor Networks," *Proceedings of the 13th Mediterranean Conference on Control and Automation, Limassol, Cyprus, IEEE*, 2005, June, pp. 719-724, ISBN: 0-7803-8936-0/05.

[62] Tokihiro Fukatsu, Masayuki Hirafuji, "Field Monitoring Using Sensor-Nodes with a Web Server," *Journal of Robotics and Mechatronics*, 2005, Vol. 17, Issue. 2, pp. 164-175.

[63] V R Singh, "Smart Sensors: Physics, technology and applications,", *Indian Journal of Pure and Applied Physics*, 2005, Vol. 43, Issue. January, pp. 7-16, ISSN: 0975-1041.

[64] Xindong Wu, Vipin Kumar, J. Ross Quinlan , Joydeep Ghosh, Qiang Yang, Hiroshi Motoda, Geoffrey J. McLachlan, Angus Ng, Bing Liu , Philip S. Yu, Zhi-Hua Zhou, Michael Steinbach, David J. Hand, Dan Steinberg, *"Top 10 algorithms in data mining"*, Springer, 2007, pp. 1-37, ISSN: 0219-1377.