Machine Learning Aspects in Wireless Sensor Network

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Abstract – With the evolution in electronic and wireless communication the cost of sensors having multi-function capability has dropped down dramatically. Also the power consumption by these sensors also came down. The sensors consists of wireless communication and capturing devices with data processing capability. Wireless Sensor Networks (WSNs) are used to collect data from physical environment. These sensors have limitations of communication capabilities because of energy and bandwidth. Thus, WSNs have inspired researchers to study machine learning strategies. This Paper aims to present, machine learning strategies. In this paper we are addressing the WSN's design issues with use of machine learning. Up-till now, various solutions are available in wireless sensor networks each of which employs number of numerous machine learning policies.

Indexed Terms: Machine Learning, Wireless Sensor Networks, Supervised Machine Learning, Unsupervised Machine Learning

I. INTRODUCTION

Recent advances that deal with the technology of micro-electronics and wireless communication have enabled the development of multifunctional sensor with low-cost and low-power. These sensor nodes consist of data processing, wireless communication and capture device. A wireless sensor network (WSN) consists of a large number of devices operating independently and communicating with radio transmissions. Many researchers have focused WSNs on two separate aspects of such networks, namely networking issues, such as capacity, delay, and routing strategies; and application issues [1]. This paper will survey the machine learning methods used in WSNs from both aspects.

WSNs technology has a promising future in many application domains. They have been used as battlefield surveillance instruments in military applications, in a construction industry for monitoring buildings, patients monitoring systems in health-care industry. Large-scale sensor network also generates large amount of data in WSNs that needs to be processed or transmitted and received. Transmitting all the data back to a central station for processing and making decisions is purely impossible due to the sensors limited energy and bandwidth limitations. WSN's works bi-directionally, i.e. transmission of information tracked from nodes to central node or base station, along with allowing control over sensor activity from the base station to sensor [2, 3]. Thus, there is a need for applying machine learning methods in WSN. This strategy could significantly reduce the amount of data communications and truly utilize the distributive characteristic of WSNs.

The WSN is collection of various enough nodes which are known as motes. Every sensor network node is made of: a radio transceiver with an inner antenna, a microcontroller, an electronic interfacing circuit and battery as a power source. A sensor node may vary in dimensions and cost of sensor nodes is also variable. The physical arrangement of WSN may be like star network or may be multi-hop wireless mesh network [4]. The transmission path between the hops of the network may be decided by routing protocol. Range of applications starting from environment monitoring to battlefield surveillance can benefit including low cost, easy deployment, high fidelity sensing. Despite of many benefits the wireless sensor networks technology comes with great challenges [5].

II. MACHINE LEARNING

The recent advances in Machine Learning (ML) methodologies enable some beneficial models to be created. The developed model might just a basic parametric function, learned from data and couple of inputs or point of view, allowing output state or variable. The WSN's can include heterogeneous, autonomous, inexpensive as well as less power sensor nodes. These nodes would be used to collect data about the physical environment being sensed and merged together for centralized control units known as base station nodes or sink nodes. The sensor nodes in the WSN might be heterogeneous designed with different kind of sensors like temperature or thermal sensors. The WSN administrators have to deal with many issues regarding collection or combination of data, data reliability, clustering of nodes, security & fault detection [6, 7].

The ML was originally launched as a unique method for Artificial Intelligence (AI). It then concentrated gradually towards algorithms which are computationally achievable and compelling. The application developed in last few years in many areas such as spam detection, bioinformatics, speech recognition, as well as fraud detection [8].

The machine learning could be defined by following definition:

- Detecting & describing consistencies and patterns in training data by employing computational methods that can improve machine performance.
- The learning processes for development of computer models that can enhance the performance of systems and offer methods to the issue of information acquisition.

Machine learning technology seems extremely encouraging according to these definitions for address issues in WSNs because it permits applying traditional data to develop the efficiency of a network on presented task, or even forecast the upcoming efficiency. For WSNs, using machine learning technology could be good for number of reasons:

- Excellent tracking of dynamic environments that modify swiftly with time. As an illustration, in soil tracking scenario, it can be possible that the location of sensor nodes may modify because of soil abrasion or ocean turbulence and WSN depending on machine learning can enable automated adaption and economical operation in such dynamic environments.
- Offering computationally possible, low-complexity mathematical models for complex environments. In these environments, it is not easy to develop precise mathematical models, and also difficult for sensor nodes to calculate the algorithm reminiscent of these types of mathematical models. Under such type of situations, WSN influenced by machine learning strategies can provide low intricacy approximations for the system models, enabling its implementation within sensor nodes.
- Augmented automation and novel applications improvement, for instance regular, ambient computing systems. WSN based upon machine learning can enable boost automation and new utilizes by integration along with other WSNs causing completely censored huge applications for instance IOT technologies, CPS and m2m communications. These kinds of applications utilize several unique kinds of WSNs and if influenced by machine learning. Nevertheless, it is relatively feasible that WSN depending on machine learning strategies may not lead to any upgrades if a few of the problems laid out below are not regarded during the design stage.

A growing usage of machine learning technologies in automation of WSNs operations has been experienced. A comparable study, however, more concentrated towards ad-hoc networks and how machine learning techniques have been implemented in ad-hoc networks is introduced in [9]. An additional seminal work on applications of three widely used machine learning algorithms whatsoever communication levels in the WSNs is introduced in [10]. A few of the work also resolved particular issues in WSNs for instance authors in, who created an effective outlier diagnosis strategy based on machine learning principles. Authors in offered a strategy depending on computational intelligence technique for dealing with issues corresponding to data aggregation.

Many of the previously focus on utilizing machine learning methods for WSNs highlighted reinforcement learning, neural networks and decision trees that were more developed in their reputation of being economical at a conceptual level and implementation level as given in [10].

A few of the machine learning algorithms to deal with functional or operation issues in WSNs such as aggregation of data, clustering, routing, localization, processing of query as well as medium access control. The operational or functional issues are those issues that are important for the simple operation of WSNs are discussed in [11, 12]

III. MACHINE LEARNING FOR WSN's

There are three kinds of Machine Learning Techniques are given below:

a) Supervised Learning

The learned relationship between output, input and parameters of the system is learned by system model. The system model is built with labelled training set is knows as outputs and predefined inputs in the supervised machine learning. This type of learning approach is used to resolve various issues for WSNs such as objects targeting & localization, processing of query and event detection, medium access control, intrusion detection and security, data integrity and QoS [12]. Some of the supervised machine learning algorithms are discussed below.

1. Decision Trees

The decision tree classification involves predicting output labels by repeating input of data using tree of learning. A significant amount of research was done in using decision trees to address different design challenges in WSN such as identifying link reliability in WSNs using decision trees [13]. Here the use of decision trees offers a general tactic for recognize critical features for link reliability including loss rate, Restore Mean Time as well as Failure Mean Time.

2. Support Vector Machines

Support Vector Machines offer alternatives for neural networks that are preferred options for solving non convex unconstrained optimization problems. In the context of WSN, they have been used for intrusion detection or detecting the malicious behaviour of sensor nodes, security, and localisation. With SVM, it is possible to uncover the spatiotemporal correlations in data, as the algorithm involves constructing a set of hyper planes separating WSN data measurements in feature space, by as wide as possible margins [12, 13].

3. Neural Networks

Neural networks are one of the most popular learning algorithms for learning from data and can built with the help of decision units cascading chains often called perception & radial basis functions. The cascading chains of decision units allow recognitions of non-linear and complex relationships in data. However, the learning process with multiple cascading chains is highly computations intensive [13, 14].

4. K-nearest neighbour (k-NN)

The K-NN is supervised learning algorithm and in this learning algorithm, a test sample data is classified based on the labels of nearest data samples. By computing an average of readings within its neighbourhood, the missing or unknown test sample measurement is predicted. Determination of a nearest set of nodes is done by using different methods [14]. One of simplest method to determine the neighborhood is by using the Euclidean distance between different sensors. As the distance measure is computed using few local points with k normally a small positive integer, the k-NN approach does not need high computational power. Due to its simplicity, the k-NN algorithm is suitable for query processing tasks in WSNs.

b) Unsupervised Learning

For unsupervised learning, there are no labels provided or there is no output vector. The sample set is classified into distinct sets by checking out the likeness between these with an unsupervised learning algorithm. This type of learning algorithm finds use in WSN node clustering or data aggregation at sink code scenarios. With no labels provided, the unsupervised machine learning algorithm discovers the hidden relationships and is suitable for WSN problems, with complex relationships between variables [14, 16]. Two most important types of algorithms in this category are K-means clustering and Principal component analysis.

1. Principal Component Analysis

This learning algorithm is quite popular into data compression field and is used for dimensionality reduction. It is a multivariate method and aims to extract important information from data in terms of principal components, which is nothing however a set of new orthogonal variables [17].

The data compression and dimensionality reduction is a multivariate method. It's objective extract crucial information from data. Also, it as a couple of new orthogonal variables knows as principal components. These principal components are ordered such that the first principal component is aligned in the direction of the highest-variance path of data, with reducing variation for additional components in order.

This permits, the minimum variance components to be abandoned as they simply include least information content, causing dimensionality decrease. For WSN situations, this could lower the quantity of data becoming transmitted among sensor nodes by getting a tiny pair of uncorrelated linear blend of innovative readings. Further, it can solve the big data problem into small data by allowing selection of only significant principal components and discarding other lower order insignificant components from the model.

2. K-Means Clustering

This unsupervised learning algorithm classifies data into different clusters or classes and works in sequential steps involving, random selection of k nodes as initial centroids for different clusters, use of a distance function to instructions every node with the nearest centroid, iteratively re-compute the centroids using a predefined threshold value on present node memberships and quit the iterations if the convergence condition is met [17]. The K-means clustering algorithm is popular in WSN sensor node clustering because of the simplicity and linear in its complexity.

3. Reinforcement Learning

This type of learning algorithm for WSNs involves learning by interaction with the environment. Here, a benefits process is involved and a sensor node learns to seize ideal measures to ensure that the lasting advantages get maximized with experience. The Q-learning is most well-known reinforcement learning algorithm useful algorithm for WSN routing problems in which each one node tries to select measures which are anticipated to increase the extended benefits. Here, the sensor node in Q-learning regularly updates the rewards it achieves based on the action it takes at a given state [16, 17].

IV. APPLICATION SPECIFIC UNIQUE CHALLENGES

There are certain unique application particular challenges which can't be classified as popular machine learning WSN literature. But, are exclusive as well as give insight into how certain unfortunate facets of WSNs were resolved. A few of these are succinctly mentioned below.

a) Self-Organizing Map Modeled Clock Synchronization

While the contemporary WSN nodes need to carry out various tasks until restricted resources, clock synchronization between sensor nodes is a crucial necessity to sustain persistence in signatory of tasks between the sensor nodes for large scale WSNs. The nodes can foretell the close to an optimal approximation of present time without a usage for middle timing device with limited storage as well as computing resources. Nevertheless, presumes that the nodes are implemented uniformly over the tracked area and virtually all the nodes possess identical transmission powers that are not invariably the case.

b) Neural networks Modeled Intelligent Lighting Control

The Radial Basis Function neural network was accustomed for removing a computational thing known as luminance Matrix for determine level of luminance in the lighted area. It is quite a distinctive application area which application field possesses various challenges concerning transforming the identified data from photo sensors to a quantitative or qualitative aspect which can prepare by computers and can consequence the efficiency of the system significantly.

V. CONCLUSION

In this paper, we have discussed issues in WSN on machine learning strategies. With the help of this study, we can suggest integrated framework, which takes into consideration both operational, non-operational and application-specific challenges to address the implement WSN based on machine learning.

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