Water Consumption Prediction Challenges And Recent Research Directions

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Abstract. Recently, water-scarce resources became one of the most urgent problems that threaten the existence of the human species. In this paper, water consumption recent research directions were surveyed while the different challenges were discussed. The proper elements integration of any proposed system is a key success for the design to allow for the necessary expansion. That can enable the optimal management of water demand to reduce water consumption and improve water infrastructure utilization. A survey has been conducted to investigate the approaches and datasets involved in water resources management to shed light on the research directions in that vital field. The authors believe that it is of utmost importance to apply such integrated technologies of the Internet of Things, Machine Learning, Cloud Computing, and the emerging 5G technology to achieve the best possible water resources management performance.

Keywords. Water resources management, Machine learning, Water quality, Internet of Things, Water supply and demand, Water pollution, and Land resources.

I: INTRODUCTION

Critical water shortages are growing causing major challenges for water resources managers around the world. Numerous enterprises exceptionally devour water and among those industries is concrete which represents the most-used construction material worldwide. Water consumption and the effective measures to diminish such consumption were discussed in [1]. In which the authors evaluated water utilization of worldwide concrete production in 2012 and mapped the production to 2050. The authors recommended potential methods of decreasing water demand by picking the suitable choice of electricity fuel mixes and improved preparation of crude materials. Their work proposed a baseline estimate for water utilization and distinguishes areas for focused relief. Another industry that profoundly devours water is coal as the predominant fuel for electricity generation around the world. This sort of power age utilizes a lot of water, expanding pressure on water resources. The authors in [2] surveyed water utilization of coal-fired power plants (CPPs) in China utilizing four cooling technologies: once-through cooling, closed-cycle cooling, air cooling, and seawater cooling. The outcomes infer that the advancement of CPPs needs to expressly think about their effects on territorial water resources. Optimization techniques, for example, Firefly algorithm (FA) is viewed as a powerful enhancement strategy that is dependent on swarm intelligence, that has been effectively applied to different designing use cases [3-9]. Wang et al. began by utilizing a unique boundary system to maintain a strategic distance from physically changing the progression factor. At that point, three assessment models in various structures (linear, exponential and hybrid) were created regarding the historical water use and local economic structure. Followed by standardization technique that was used to wipe out the impacts of various units of information. In their tests, water use in Nanchang city from 2003 to 2015 was considered as a contextual investigation. The proposed NDFA got preferable exhibition over four other FA variations, and its forecast exactness was up to 97.91%. At last, the water interest in Nanchang city from 2017 to 2020 was predicted [10]. As a holistic Integrated Water Resources Management (IWRM) model is hard to execute and the complexity related the high-dimension optimization problems. These difficulties anyway have propelled a couple of investigates to build up an extensive optimal methodology. In a research by [11], the authors methodology utilized the economic, social, and environmental objectives for river basin management. An investigation by [12] gave a specialized outline and transdisciplinary progress update about the pertinence of Deep Learning (DL) to water. The survey uncovered that different physical and geoscientific disciplines have used DL to address information challenges, improve productivity, and increase the use of knowledge. DL is particularly appropriate for data extraction from image-like information and successive information which is highly dependent on the type of image and processing task [13-19]. Methods and encounters introduced in different controls are of high significance to water research. Therefore, many opportunities exist for DL to be utilized in water sciences by investigating different color and spectral images [20-24]. An exploration by [25] utilized framework elements to partition the macroeconomic components that influence the practical utilization of water resources into five significant subsystems: economy, populace, water gracefully and request, land assets, and water contamination and the board. They found that a fair advancement program can accomplish consistent financial development, give a segment profit, ensure arable land assets, and improve the reutilization proficiency of water. In [26], a support model for the ideal treatment and distribution of water resources was introduced. The authors model intended to limit the complete water cost which incorporates the financial expense of treatment and dispersion, just as the related natural expenses. Their model was novel in its capacity to represent spatially dispersed water flexibly and request hubs, just as various water and request types and characteristics. It accommodated different treatment advancements, distinctive energy recuperation levels, and asset availabilities or limits. The ideal arrangement yielded volumes of water moved from each gracefully source to every treatment plant and treated by a proper innovation to fulfill water demands at various required water characteristics with the most minimal in general monetary and natural expenses. In business terms, water governance and stakeholder engagement are getting research consideration for their function in defining and executing answers for the world's basic water difficulties. The authors in [27] provided a platform to sharing outcomes and advising the worldwide water administration network about the abundance of magnificent interdisciplinary and transdisciplinary exploration and tasks being done far and wide.

II: IOT FOR WATER CONSUMPTION

The smart water metering systems have recently started to pick up force as water utilities began to utilize real-time data acquisition that can be stored and utilized in information examination to spare the scarce water resources in an ideal manner [28]. One of the most significant exploration headings supporting that pattern, is advanced metering infrastructure (AMI) that can offer a remote connection between water utilities [29]. However, the correspondence itself can take numerous structures, for example, cellular transmission, power fiber optics, and broadband communication among others [30]. In smart water metering framework, information can convey between savvy meters and water utilities with the help of expository programming design to take a smart choice in regards to specific activities to screen and control the water gracefully or to give appropriate alerts to consumers or guide them [31]. It can likewise foresee examples in water utilization for future estimate. Because of the multifaceted nature engaged with the water framework that incorporates siphoning stations, repositories and purchaser benefits, the expectation if exact enough can help controlling water utilities in a manner that keep away from water systems issues that may emerge in the hours of pinnacle utilization or water leakage [32]. When a smart water metering communications network is deployed, water utilities need to pick the correct technology to use in information transmissions. As there is a various number of choices that contrast in cost, prominence, dependability, versatility, and security among different markers, picking the correct engineering and correspondence advances can introduce a boundary to water utilities [33]. Water utilities joining should be arranged cautiously to guarantee their interchanges network is enduring [29]. The amount of forward-planning can be considered an issue to adopt water utilities' solutions. Therefore, the proposed design discussed in this research can offer a feasible solution that can help countries aiming to incorporate the up-to-date IT technologies in communication, machine learning [34], computer infrastructure and smart meters to save their scarce water resources which return on the economy with tremendous savings and benefits. IoT can be seen from 'Internet' perspective and 'Thing' perspective. The Internet perspective architecture involves internet services representing the main objective while data is contributed by the connected objects. While in the object perspective architecture, the smart objects are the focus point [35]. An abstract framework that integrates both the ubiquitous sensing devices and the water management services is shown in Figure 1. Therefore, to realize the full potential of ubiquitous sensing as well as cloud computing, a combined framework with cloud computing at the center is considered the most viable. Consequently, the framework can give flexibility of dividing associated costs in the most logical manner while keeping the system highly scalable. Sensing service providers can be added to the network and provide data storage using cloud storage; while the analytical tools can be seamlessly integrated; AI and data mining services can convert information to knowledge that can offer features that could not be achieved otherwise. Moreover, the cloud computing can offer these services as IaaS, PaaS or SaaS where the full potential of smart services can be engineered using such services [36]. Generated data, tools and visualization services can expose the full potential of the IoT in various application domains without the complexity associated with such systems which is hidden underneath.

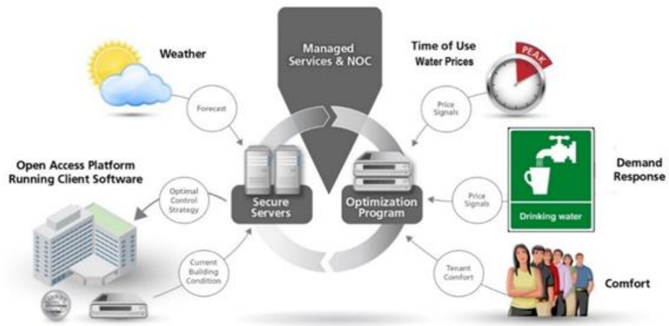

Figure 1: *Smart water management system.*

III. WATER PREDICTION TECHNIQUES

Water advancement and sparing endeavors have centered around expanding client shopper mindfulness by formulating mediation situations that target teaching clients about their demand behavior and guide them to decrease their utilizations. Examination on information mining and AI procedures were water utilization forecast and example acknowledgment and on mediation strategies that misuse these methods to educate buyers and animate social changes [37]. Additionally, organizations are putting resources into water observing gadgets that are introduced on family washroom fixtures and estimating continuous water utilization, for online measurements and sending cautions to the customers [38]. These intercessions and cautions necessitate that individual transient utilization to be anticipated as precisely as could be expected under the circumstances and continuously so they can be contrasted and future arranged utilizations [39]. A few delicate processing strategies have been created during the most recent couple of a long time for water demand prediction. Ghalehkhondabi et al examined the delicate processing techniques used in water utilization published between 2005 and 2015. They found that while in momentary estimating, ANNs have been prevalent, however it is still exceptionally hard to pick any strategy as the general best [40]. In literature, different methods were applied to water demand prediction. Meanwhile, it was shown that soft computing has a lot more to contribute to water demand prediction research [41]. Muhammad, and Feng checked on urban water demand forecasting using various artificial intelligence-based approaches. Their examination represented how the diverse computerized reasoning methodologies assumes a crucial function in urban water request estimating while at the same time suggesting the utilization of ANN for transient interest anticipation [42]. Papageorgiou et al proposed a hybrid approach for time series prediction. The recommended technique was utilized for choosing the important attributes and interconnections among them which were utilized as the information to ANN for time series prediction. The exhibition of the proposed approach was introduced through the examination of genuine information of everyday water interest and the relating expectation [43]. Shabani et al proposed a Support Vector Machine (SVM) model, utilizing polynomial portion capacity to conjecture month to month water demand to assess phase space reconstruction before the plan of models' information factors blends. Their outcomes demonstrated that ideal slack season of the information factors can essentially improve the exhibition of SVM models [44]. Nowadays, using cloud computing services is getting exceptionally mainstream among enterprises and ward clients as a result of its flexibility and diverse facilities [45-47]. Along these lines, interest for its infrastructures is expanding exponentially and with this enormous development of requests, it is getting all the more trying for cloud suppliers to serve all the client demands such that quality of service is high enough and service level agreement is additionally met [48]. Narayanan et al designed an IoT water distribution architecture to be used in a smart city. The water demand gauging has been completed day by day for a time of a quarter of a year as a contextual investigation utilizing ARIMA and regression analysis. A water distribution design utilizing hydraulic engineering for appropriate circulation of water would bring about the advancement of a savvy water dissemination framework [49].

VI. DATASETS FOR WATER DEMAND PREDICTION

A couple datasets are utilized in writing that are identified with water quality, surface water, and family water utilization. The most remarkably is USGS datasets [50] which offer water-resources information gathered at roughly 1.9 million sites in USA. Online admittance to this information is composed around surface water, ground water, water quality, and water use datasets. As water quality monitoring is an urgent perspective to ensuring water resources. Under the Perfect Water Act, state, tribal and federal agencies monitor different water resources. The information created can help water resource managers to associated issues [51]. The UN Environment GEMS/Water Data Centre gathers, controls and gives water quality observing information and items for local and worldwide water quality evaluations. The Server farm keeps up the worldwide water quality data set and data framework GEMStat. These are government establishments and offices with the official order to screen freshwater quality information in their nations [52]. Water NSW works a wide scope of water checking programs estimating surface water level and stream, groundwater levels, stockpiling level and volumes, and surface and groundwater water quality and natural conditions. The checking includes a blend of programmed computerized sensors and logging gadgets just as manual testing. All the information from these exercises is then grouped inside a focal information base framework [53]. Another dataset that was acquired from a regional area in Cairo recording the water consumption from different households for a period of one year [54].

V. CONCLUSIONS

This work aims to survey the recent research directions of water resources and the most common datasets that can be used statistical analysis and machine learning techniques. Several paradigms were proposed in the literature that relied on which use case is considered.

The smart water meters design and their integration in the IoT offers a viable method to monitor drinking and surface water as well as water consumption in different industries and activities. The active projects that applies modern approaches to regional use cases among many countries can give insight to the know how to develop a complete paradigm that can work effectively when national scale and integrity is a concern. Real-time streaming is critical for additional handling and conceivable expectation for basic administration circumstances. Thusly, any proposed worldview should exploit the rising innovations, for example, as containers and micro-services opposite to virtual machines cloud architecture to speed execution and decrease cost on the national scale IoT framework used to gather water utilization information to take into consideration the extension to cover the entire nation. Another significant innovation that is firmly connected to the IoT is the 5G that can include better data transmission and better handling capacities which are a key accomplishment for developing smart water management systems. The principle importance of the testbed is to gather aggregated water consumption from various areas to be utilized to accomplish a disconnected utilization model dependent on time and region. That can be trailed by continuous forecast for the water demand with a versatile AI application. In view of the water demand expectation various situations for both water utilities the executives and customer behavior the board can be incorporated to a definitive objective of decreased water utilization. Likewise, this exploration recommends an administration framework that requirements to offer quantitative measures for water demand reduction in top occasions, better water request conveyance, and better water utilization. Additionally, it needs to quantify the impact of arranged city advancement and extension that pressure the water network infrastructure. Hence, the researches that offer testbeds for water utilization are viewed as an initial step to be joined in a water demand management system that can be scaled up on a national scale with incorporated administrations thinking about security, cost, and versatility.

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