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Review Paper on Detection and Measurement of Water Level using IoT Applications

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Abstract— ***This paper presents a review on detection and measurement of water level using Internet of Things (IoT). With the emergence of new technologies such as sensors, remote sensing, LoRaWAN, advance computing etc. many new systems or techniques have evolved from the traditional ones. It has converted the old-school technique into sophisticated techniques to measure and detect water or liquid level. The gathering of liquid level data has become faster, easier, and more reliable. Using IoT, the new systems for detection and measurement of liquid level has greatly increased its scope of applications. This review provides important insights into the latest designed and developed techniques or systems.***

Keywords: Sensor, detection, measurement of water level, IoT, LoRaWAN, reservoir.

I. INTRODUCTION

About 70% of the Earth's surface is covered by water and about 97% of this is found in seas and oceans. Only 3% is available as fresh water (www.usbr.gov). The water is found in oceans, rivers, lakes, ponds, wetlands etc. Management of these waterbodies are vital for the survival of mankind. One of the important tasks of water management is detection and measuring of water level [7]. This has led to the development of many advanced systems or techniques using Internet of Things, LoRaWAN, Remote Sensing, Thermal Infrared (TIR) imaging etc. which are being used in reservoirs, canals of irrigation system, floods, public water supplies, industries etc. Different types of technologies are used to gather data from water tank to vehicle fuel tank, irrigation canals to hydropower dams, public water supply to industries, reservoirs to lakes etc. Moreover, uses of sensors, acoustic doppler current profiler (ADCP), synthetic aperture radar etc. have also been reviewed.

II. DETECTION AND WATER LEVEL MEASUREMENT SYSTEM

The working principle of this detection and measuring system is actually very simple [7]. It works by using a device called sensor. It can be either contact type or non-contact type. When the contact type sensor is put into the water of tank to be measured, the sensor probe detects the level of water. The sensed quantity is converted into proportional electrical quantity and sent back to the control panel to activate an indicator or alarm. Figure 1 shows the basic working principle of water level measurement & detection system.

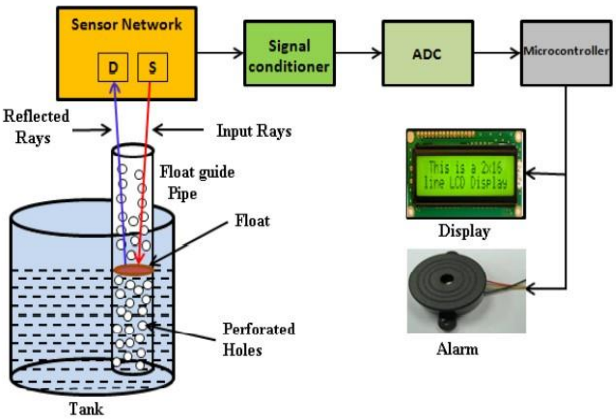

Figure 1. Block diagram of detection & water level measurement system [7]

2.1. Internet of Things (IoT)

The Internet of Things or IoT is the network of things (Objects) such as vehicles, lighting system, smart watches etc. that are connected to the internet, all collecting & exchanging data with other devices & systems. Figure 2 shows the general block diagram and working principle of IoT.

Figure 2. Block Diagram of IoT

The IoT is one of the most advanced & latest technologies in the field of communication [19]. It has evolved due to the merging of new and advanced technologies such as information technology, embedded systems, advance computing, sensor & controllers etc. The use of IoT in detection and liquid level measurement has greatly increased its scope of applications.

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III. LITERATURE REVIEW

The gathering of data from industrial applications (such as public water supply systems, oil containers etc.) reservoirs, water canals, floods etc. has never been easy. But, with the emergence of new technologies the things have changed drastically. It has made the gathering of data faster and easier. Important techniques or systems which have been designed and developed until recently are reviewed in this section.

Saleem Latteef Mohammed et al. [1] proposed a non-contact water measurement system. The authors used Ultrasonic sensor and Microcontroller to measure volume and level of water. The proposed system provides automatic control for liquid deficiency or surplus in a tank. Alarm system has also been used for warning purpose.

K. Loizou et al. [2] reviewed number of sensors applicable for measuring liquid level. The authors found that cheap, portable, long range and highly accurate sensors are necessary for large water management systems. So, they chose the most appropriate one i.e. capacitive sensor for measuring water level.

J. F. Cretaux et al. [3] used satellite altimetry to measure water level of lakes and reservoirs with respect to gauge stations. The authors found that satellite altimeter is most suitable for larger water bodies as it gives highest accuracy. Accuracy decreases from larger, intermediate, and then to the smaller lakes. F. M. Javed Mehedi Shamrat et al. [4] proposed an automated system for passenger vessels. The system detects the overloaded vessels with their accurate locations and alerts the command centre through SMS for prompt action. The authors primarily used float switch and GPS for water level and location detection.

Brajesh Kumar et al. [5] reviewed various methods for measuring level of liquids. The authors found that capacitive sensor is the most suitable for industries. It can measure liquid level upto 80 cm effectively. M Duane Nellis [6] used Thermal Infrared (TIR) imagery to locate leakage in canal of North Unit Irrigation District. The author found that it is economical if TIR is used to sense in the range of 8 to14 micro meter of electromagnetic spectrum. Nirupam et al. [7] designed an inexpensive water level measurement model. The model is self-calibrated & can measure till 225 cm of water level and beyond. It has an error of just ±2 per cent which is within the permissible limit. The authors also reviewed the various types of sensors such as float switch, ultrasonic sensor etc. Table 1 shows comparison of few types of sensors.

Table 1. Comparison of few types of sensors [7]

	Pressure type	Float/Encoder type	Radar type	Ultrasonic type
Advantage	▪ Extensive range of measurement ▪ Convenient installation	▪ Wide adaptability to water quality ▪ Low power consumption	▪ Non-contact measurement is possible ▪ Accuracy in measurement ▪ Wide range	▪ Non-contact measurement ▪ High measuring accuracy
Drawback	Precision is affected by density of water	Big cumulative measurement errors need recalibrated frequently	Expensive; measured procedure is affected by raindrop & snowflake	Ultrasonic speed is affected by temperature & humidity of the transmission medium; small measured range
Precision	±0.1~0.3% of full scale	±0.2~0.3% of full scale	±3~10 mm	±0.15% of full scale
Suitable range	<100 m	<40 m	<90 m	<0.25~12 m
Cumulative Error	>2 cm monthly	>2 cm daily	NA	NA
Absolute Error	<2 cm @measured range<20 m; >2 cm @measured range>20 m	<2 cm @measured range<10 m; >2 cm @measured range>10 m	±3 mm~10 mm	<2 cm @measured range<13 m; >2 cm @measured range>14 m

Shyju. S et al. [8] concluded that physical monitoring of dam parameters takes a lot of time and causes inaccuracy. The authors used predictive system using Internet of Things to mitigate flood which gives data in real time with greater accuracy. Gaia Codeluppi et al. [9] employed an inexpensive Internet of Things (IoT) Architecture using LoRaWAN to enhance the farm-management. In order to evaluate in real time for 3 months, the authors installed 4 sensor nodes namely ENs and INs in both vineyard and greenhouse and gathered data such as temperature, soil humidity and air required for proper growth of grapes & vegetables. This is highly adjustable platform and evaluated in a real farm located in Italy. Sang-Hoon Hong et al. [10] used small temporal baseline subset (STBS) to observe changes in

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absolute water level instead of conventional InSAR methods which gives values of relative water-level. Hydrologists prefer values of absolute water-level of marshlands which can be easily calibrated.

Meimei Zhang et al. K. Chetpattananondh et al. [12] successfully put forward the system for measurement of water level. The authors used interdigital capacitive sensor for the system. The experimental outcomes show that the sensor is simple, efficient, cheap and consumes less energy. The most significant result is that the sensor can instantly measure the rise and fall of the water wave. Moreover, the use of two comb electrodes has made the system free from calibration. Kristoph-Dietrich Kinzli et al. [13] used a device called acoustic doppler current profiler (ADCP) to measure water seepage in canal. ADCP is technologically more advanced than the flowmeters and conventional inflow-outflow technique.

Sandhya Rani B et al. [14] proposed an IoT based monitoring system which is very useful for identification of fuel theft & tracking of location of nearby petrol pump. The ultrasonic sensor has been used to measure the amount of fuel. This system is accurate & monitors in real time. Songlin Chen et al. [15] focused on problems like intelligent maintenances, intelligent scheduling, rapid market responses and intelligent response for consumers in IoT-smart grids. The authors proposed intelligent edge computing in IoT smart grids to solve the problems in current cloud computing. Numerical simulations have shown the effectiveness of proposed edge computing system.

Yizhi Tian et al. [16] found that conventional methods take a lot of time to calculate potential of water in river. They are costly & have errors. The authors used Geographic Information System (GIS) software to calculate the total potential in place of conventional methods which took lesser time & produced better outcomes. Mukesh Bathre et al. [17] found that by using solar and water energy a sustainable hybrid energy harvesting system can be developed. The developed system can reduce the power consumption to 21.2 mW. With the help of battery, it can last up to 432 hours. Using LoRa communication real time data of water level and status of battery can be obtained for years.

Sai Sreekar Siddula et al. [18] used Internet of Things and sensors to develop an advanced Water Level Management System. Using this system, the real-time data on water levels can be collected & shared to the authorized command center. In this way, the operation of dams located in every nook and corner in the country can be easily automatized as well as centralized. Yasin Kabalci et al. [19] found that Energy Internet is a latest idea for future grids. It is synonymous to energy management system. It consists of smart grids, intelligent systems, smart elements, and communication systems. To combine the communication and data management systems with generation, transmission & distribution, Internet of Things has been used.

Swapnil Bagwari et al. [22] studied inexpensive sensors & LoRaWAN for monitoring Landslides. The authors found that landslide monitoring system for small area can be realized using sensors and wireless networks such as LoRaWAN. They suggested for collaborative & alterable landslide monitoring system. Agastya Vitadhani et al. [26] simulated the early warning system for flood using LoRaWAN. The authors concluded that at least two gateways are needed for Ciliwung River. The first area covered Bogor by one gateway having thirty meters in height. The second area covered Depok and South Jakarta by two gateways having thirty meters each in height or by one gateway having one hundred & eight meters in height.

IV. RESULT

Table 2 shows some of the main results of literature review in chronological order.

Table 2. Main results of literature review

Reference	Paper type	Main result(s)
M Duane Nellis (1982)	Experimental	• It is economical if TIR is used to sense in the range of 8 to14 micro meter of electromagnetic spectrum.
J. F. Cretaux et al. (2011)	Experimental	• The satellite altimeter is most suitable for larger water bodies as it gives highest accuracy. • Accuracy decreases from larger, intermediate, and then to the smaller lakes.
Brajesh Kumar et al. (2014)	Review	• The capacitive sensor is found to be the most suitable for industries. • It can measure liquid level upto 80 cm effectively.
Nirupam et al. (2015)	Experimental	• An inexpensive water level measurement model was designed. • The model is self-calibrated & can measure till 225 cm of water level and beyond. • It has an error of just ±2 per cent which is within the permissible limit.
K. Loizou et al. (2016)	Experimental	• The cheap, portable, long range and highly accurate sensors are necessary for large water management systems. So, the most appropriate one is found to be capacitive sensor for measuring water level.

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Reference	Paper type	Main result(s)
Saleem Latteef Mohammed et al. (2019)	Experimental	• The Ultrasonic sensor and Microcontroller were used to measure volume and level of water. • The system provides automatic control for liquid deficiency or surplus in a tank. • Alarm system has also been used for warning purpose.
F. M. Javed Mehedi Shamrat et al. (2019)	Experimental	• The system detects the overloaded vessels with their accurate locations and alerts the command centre through SMS for prompt action. • Float switch and GPS were used for water level and location detection.
Shyju. S et al. (2020)	Experimental	• Physical monitoring of dam parameters takes a lot of time and causes inaccuracy. • The predictive system using Internet of Things is found to be the best solution to mitigate flood.
Gaia Codeluppi et al. (2020)	Experimental	• An inexpensive Internet of Things (IoT) Architecture using LoRaWAN was used to enhance the farm-management. • This platform is found to be highly adjustable and evaluated in a real farm located in Italy.
Sandhya Rani B et al. (2022)	Experimental	• An IoT based monitoring system was developed for identification of fuel theft & tracking of location of nearby petrol pump. • The ultrasonic sensor has been used to measure the amount of fuel.

V. CONCLUSION

The evolving of new technologies has added new dimension to the detection and water level measurement system. We carried out a comparative study on new and latest measuring techniques. We have noticed that techniques used for vehicle fuel detection, irrigation pipes or canals, reservoirs, leakage detection, floods, boilers, industries etc. are simple and mostly inexpensive. But the techniques such as remote sensing, ADCP, TIR imagery etc. are expensive. They are mainly used for larger & complex problems. For example, detection of water level of wetlands, floods, larger waterbodies, and their characteristics. The use of IoT with latest sensor such as ultrasonic sensor has made detection and liquid level measuring system cheaper. It has also made it faster, more reliable, more accurate, more efficient, and wider reaching. But IoT does not work in mobile or internet shadow zone. Such shadow zones exist everywhere mainly due to geographical features. In such locations, LoRa and LoRaWAN can be used to connect IoT devices.

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