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A Systematic Review of Industrial Automation on the Water Level Measurements by Embedded and Open-Source Software



Abstract

In the recent days, industrial automation become an incentive force in all industries. The growing organisations emerge the automation techniques in various applications like manufacturing, constructions, etc. for increasing efficiency and productivity. Every innovation had start from the state-of-art within the respective domain by innovative technologies. Automation technologies like Internet of Things (IoT), Artificial Intelligence (AI), cloud computers and so on. To measure and control water level in the tank is set up by cascaded and coupled mechatronics systems are used to identify, measure and control water level by the sensors. The issues in the water tank is minimized by smart monitoring techniques based on IoT can able to monitor liquid level, pipes leakage and auto control of pumps. Common type components of industrial control system are Supervisory control and data acquisition (SCADA), Programmable logic controllers (PLC), Distributed control systems (DCS), Proportional-integral-derivative controllers (PID) and so on. PID along with PLC is widely used in industries to increase the capabilities by the simulation of MATLAB/Simulink software. The steady-state-error is minimized by increasing robustness in the control algorithm in a closed loop. In this paper, MATLAB simulations and machine learning techniques that are used in water tank system to increase the performance by tracking accuracy and minimize the error are briefly discussed. These are analysed on the basis of water tank system types and other programming environments that are involved in control techniques. The evaluation related to existing methods are studied and the future scope challenges are analysed.

Keywords: *Industrial automation, Proportional-integral-derivative, MATLAB/Simulink software, Fuzzy-PID, Internet of Things.*

1. INTRODUCTION

The dynamic problem in the water level measurement is occurred in various fields like chemical industries, mining, transport industries, etc. Industrial automation is controlled by various control devices are used to control the industrial applications without the human intervention and provide automatic control process [1-2]. The technique of industrial automation enables high mass production cost and the introduced technologies reduces the production cost. The functioning of the automatic control system not only affects the process of the device but also affects the quality of the environment [3-5]. The importance of this system is to improve the new measuring instruments with the efficient programming computers and the numerous amount of techniques are evolving fast in the recent years. The concept which is included in the dynamic observation in the wireless phenomena is to monitor the production strategies [6-8]. Developing the methods to produce and storing liquid is the dynamic control process with the methods that are already exist to transfer the concepts and embedded them to improve the programming environment by modern techniques. The tested object in the real state imitate the numeric methods based on the involvements of advanced programming algorithm [9-10]. From all of these, automation plays important role in industrial process by the performance of Supervisory Control and Data Acquisition (SCADA) systems. The management of water flow is controlled by transmission and distribution of

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products in the manufacturing unit and also employed in other automation service. The control devices like Programmable Logic Controller (PLC), Intelligent Electronic Device (IED) and Remote Terminal Unit (RTU) are used to monitor electrochemical equipment's and transmit signals to the control devices [11]. In production, artificial intelligence is used in automated machines. The applied techniques provide guarantee for the accuracy and production quality in the production process [12]. Enhancement of IoT consumes large energy for fault detection, increasing efficiency etc., and so in order to reduce energy conservation using cloud server [13]. The main objective of this work is to make wide, unique and concise overview of intelligent machines and designed mathematical methods that are developed to control and measure the water level in the tank by numerous configurations [14-15]. The overview of few sections are split and the design are developed by using hardware mechatronics, mathematical modelling, computer software etc. Some techniques in the control strategies are single tank system, two tank system and multi tank system. These control system allow the numerical methods and the prediction of actual water level, increasing accuracy in the regulation process. Several approaches that are used to monitor and control the industrial applications by PLC, SCADA, Wireless Sensor Network (WSN), IOT etc. PLC technique are widely used to increase the reliability, quality, and reduce the production cost. From all of these IOT comprises more convenient for monitoring process in industries [16].

Section 2 discuss the research papers that are used in the present review work and section 3 presents the role of software in the liquid level control system. Section 4 presents the description of water tank system and section 5 describe the concepts of IoT in water tank control system. Section 6 discuss the types of dynamic water tank system. Section 7 discuss the review based on single tank dynamic system, section 8 discuss the review based on two tank dynamic system and section 9 discuss the review based on multi tank system. Section 10 presents analysis of methodology and challenges in the water level control system and section 11 completes the review by future enhancement of water level control system.

2. RESEARCH ANALYSIS

A review of 40 to 50 papers are study from the respected journals like Springer, IEEE, Elseiver, etc., and the papers are from 2016 to 2022 based on industrial automation, Fuzzy PID, Internet of Things using MATLAB/Simulink software. Review of this paper differ from the recent reviews and contains control methods and future scope of water tank system. Fig. 1 represents the count of selected articles.

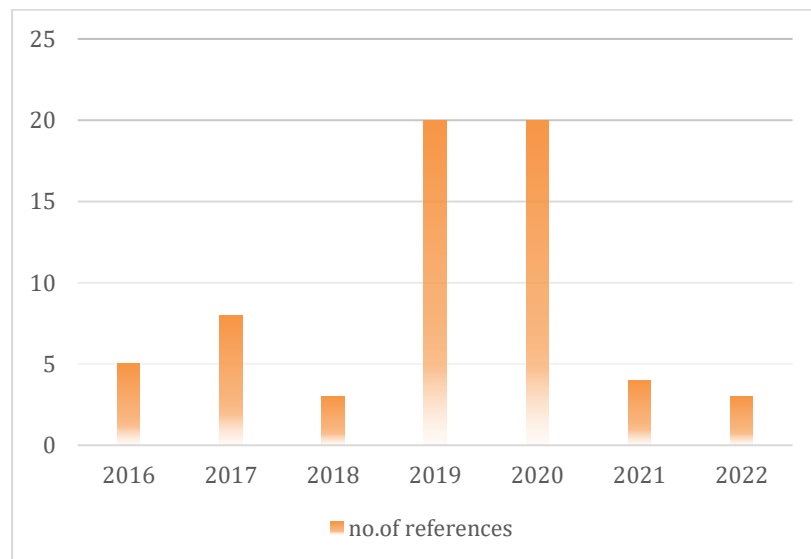


Fig. 1. Counts of article selection

3. THE ROLE OF SOFTWARE IN THE LIQUID LEVEL CONTROL SYSTEM

The liquid level are controlled by many techniques which are involved in the realization of numeric coding by real system or virtual systems. These methods are simulated by programming languages or in MS Excel. The microcontrollers in the hardware side creates a logic unit and can able to control the output by the prescribed algorithm. It can able to operate in the Single Input Single Output (SISO) or Multiple Input Multiple Output

(MIMO) object of control. These control systems can modify the code of high-level programming language into machine can understand code by installing a programs in an on-chip memory. The programs are stored in the electronic units that are managed with the memory and it is treated as a flash memory. The pre-programmed is obtained as read-only memory and it is being a one alterable field or this is even like the embedded system in the gate array of field-programmable reconfiguration. For this process, MATLAB/Simulink are used in the control scheme representation and other programming environments are also discussed.

3.1 MATLAB / Simulink environment

Water level in the tank is controlled and monitored by traditional method is insufficient to solve the complex problems. To overcome this complexity by introducing a method of some parameters including Proportional-Integral-Derivative (PID) parameters are used in the Simulink software to simulate the techniques by the system nature.

Liquid level is controlled by adding Arduino blocks in the Matlab/Simulink embedded software. This is carried out by advanced on-off PID controllers like ANN-PID and Fuzzy-PID is used to simplify the design and shortens the time [17]. Using Matlab simulations, the implementation of Fuzzy PI and Fuzzy PID controllers are used to enhance the performance in monitoring the liquid level in the hopper tank [18]. The disturbance in the multi tank system is controlled by introducing Linearized Active Disturbance Rejection Control (L/ADRC). By the process of L/ADRC, disturbance are reduced by the PID controller [19]. In some techniques the disturbance cause unstable response in the flow. To eliminate this issue by Adaptive Fuzzy-PID (AF-PID) is used to control the liquid flow by heating tank system by re-tuning the controller [20]. The performance and the control methods in the tank is controlled by PID to determine the quantity by the volume of the tank. Adaptive neuro-Fuzzy Interference System (ANFIS) have the ability to adopt learning parameters than the Fuzzy-PID methods. The Simulink of PID-ANFIS with the combination of artificial intelligence are used to solve various problems in the control system [21]. The hybrid of fuzzy-PID is the technique using Matlab software improves the stability of the pressure station. The raise in time does not make too complex problem in the optimization because all controllers have almost same raise in time [22].

3.2 Other programming environment

The study purpose is carried out to regulate water level in the tank by Xcos software. The main functionality in the software system to increase control performance by using Xcos platform. The implementation process which controls the tuning process to carry out the disturbing factors and control variables [23]. The LabVIEW interface of Java-Internet-LabVIEW (JIL) completes the process of data exchange and allows interaction with the PLC. The automation technique relates process of Fuzzy control of a DC servo motor are carry out by PLC [24]. The most commonly exploited simulation environments are designed for virtual control systems are connected with the control strategies and theoretical analyses. These are developed by applying methods of Scilab/Xcos environments with the general proposing languages of Java or C++. From the overall review reveals the possibility and areas of application of the inspected software.

4. DESCRIPTION FOR WATER TANK SYSTEM

Large containers that are used to store water through pipes and supply to wherever it is needed. In industries a large size tank is used to save water or any other purpose like storing of chemicals, oil, fuel etc. To control and manage the water level in the tank is a difficult process so, it needs automatic control and management system by means of industrial automation techniques. In the automatic techniques use sensors for the on-off function in the pump and detect the errors in measurement and the sensors are cost effective and last longer than other devices. By the process of sensing, the system detect the availability of water in the tank and then the pump perform on-off function based on the information [25]. Monitoring techniques like Industrial automation and Control System (IACS) and SCADA plays important role in cybersecurity monitoring. SCADA systems focusing on complete frameworks and theoretical machine learning approaches in the systems of anomaly detection [26]. The designing of the dynamic control system is based on the analysis of fault tolerant control and fault detection in the automatic control and it is developed by embedding to indicate the fault tolerant margin [27]. The control automation systems use methods of Expert System based on Production Rules employing Binary Logic (ES-PR-BL) and Expert System based on Production Rules employing Fuzzy Logic (ES-PR-FL) are used in

simulation for getting water tank level control, control angular velocity in DC motor and linear velocity in vehicle. Fuzzy logic have expert system with production and control the dynamic devices [28]. In the industrial automation PLC is a key building block of ICSs for maintaining the feedback control loops in low regulatory system. A prototype of IOT-PLC generates traits in 4.0 industrial revolution and can able to monitor the water level, errors in detection, etc. [29]. From the overall performance in the water tank management and control system based on industrial automation is to monitor the liquid level in the tank, reduce the energy consumption, automatic on-off function in the pump and error detection.

5. IOT BASED WATER TANK CONTROL SYSTEM

IOT is the intelligent technology to provide a number of applications like environment monitoring, health, commercial area monitoring, etc. The production cost is very convenient in industries to increase the reliability and quality. IOT is used in industries to achieve monitoring process in the water tank system and it connects the physical objects in the internet. This communication system is made up of embedded software with the help of wireless sensor network devices and monitor and control the process by mobiles or laptops. It decreases the complexity and increases wireless communication in the IOT. In addition, the fault probability, number of cables in the industrial system are reduced by wireless communication system. IOT technique was developed by WAN (Wide Area Network), NodeMCU (Node Microcontroller) Unit, ZigBee, Bluetooth, Nano station etc. This technique can control the issues in converting physical objects to active objects in the embedded system and the issues in gathering object signal.

In the recent days, the real time monitoring is implemented using IOT. Hybrid of classical PID and the Fuzzy logic are the two control that are used to control and monitor the process in industries. Fuzzy system is simulated by using MATLAB-R2018b and then modify it by PLC based on Sugeno method and object Process Controller (OPC) server is used in the sensor by the protocol of Modbus [30].The control of 4-state switch is developed for the manual systems using IoT in off mode state. Multi Intelligent Control System (MICS) provides satisfactory and convenient for monitoring water level in the industries as well as domestic. This increases the efficiency in water management system [31].The intelligent system based on IoT is used to monitor water in the depth level. Arduino UNO is developed to calculate the water level accurately by introducing the technology of GSM to alert a call for the user without the internet [32].The live prediction of the water is monitored, analysed and stored the reliable data in the process of sensors and indicates the functionalities by IoT based Wireless Sensor Network (WSN). This is implement by HC-12 and Django, provide a better transmission of data that is generated by sensor using analysing tools in machine learning techniques [33].In order to access the water level and the performance in two tank system is monitored by IoT. Using IoT technique, water level is detected by the reflection of sound echo by the sensing inspection of either active or passive. The hardware components like pH sensor, ultra sonic sensor, turbidity sensors are used to develop the chart in the operation system [34].Using Blynk method based on IoT is the smart technique to measure the height of water and the reservoir is implemented properly. In the automation technique, pump automatically stop when it reaches 100% of water level in the tank. That acquires the error value of 3% and is implemented in the large industries to reduce the energy consumption in the water spills [35].

6. TYPES OF WATER TANK DYNAMIC SYSTEM

The series connection of tank system is nonlinear due to cascaded tank system and these nonlinearities are transferred to pumps, dynamic valves or sensors. The system models are based on the equation of flow balance or the flow resistance estimation on contraction lines. The control of water level in the tank system is based on the efficiency of height of the water source that is placed higher in the height of water tank. There are three types of working principles in the sensors to measure water level in the tank. They are float switch sensor, probe level sensor and ultrasonic level sensor. In the working principle of float switch sensor, the sensor device is connected electrically to the motor. In this principle the device is floating on the water and monitor water level in the tank. The sensor of probe level working as the principle of assigning various levels in the tank. In this principle of on and off mode in the motor when the probe hits the assigning level. In ultrasonic level, uses ultrasonic sensor and the layout board. This is working as the principle of on-off mode and the needs are specified in the program and executed by sensors. This dynamic water tank system is divided into single water tank system, two water tank system and multi water tank system.

6.1 Single water tank system

Single water tank system is a dynamic system that water can flows continuously into the tank and continuously flow out of the tank. The flow control of water level is one of the parameter widely used in all industries. So, liquid level control technique is most efficient and important aspect of all industries. In this technique the pump automatically control the flow of water as soon as the water touches the upper or lower level of the tank. The non-linear characteristics of single water tank control system is focused on the realization of algorithms based on Fuzzy and neural network PID controller with the simulation of MATLAB software [36].

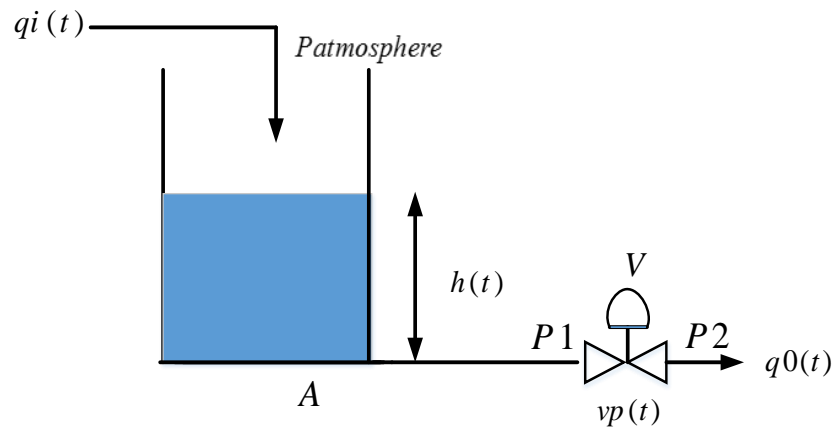


Fig. 2. Single tank system

Fig. 2 represents the schematic representation of single tank system. Where, q^i represents inlet volumetric flow rate, q^0 represents Outlet volumetric flow rate, h represents height of liquid in the tank, V represents valve coefficient, A represents cross sectional area of the tank.

6.2 Two water tank system

In the industrial control process the coupled system is commonly used system and the liquid flow between the two tank systems by means of the connection of two valves contains inlet and outlet. The principle of two tank system is to maintain a constant liquid level in each tank. The technique in the control system was developed by applying both Fuzzy control system and conventional control system. The corresponding model was implemented and simulated by MATLAB/Simulink software. Based on the configuration, two tank water system is classifies as One control inlet and one outlet, One control inlet and two outlets, Two control inlets and one outlet, Two control inlets and two outlets [37].

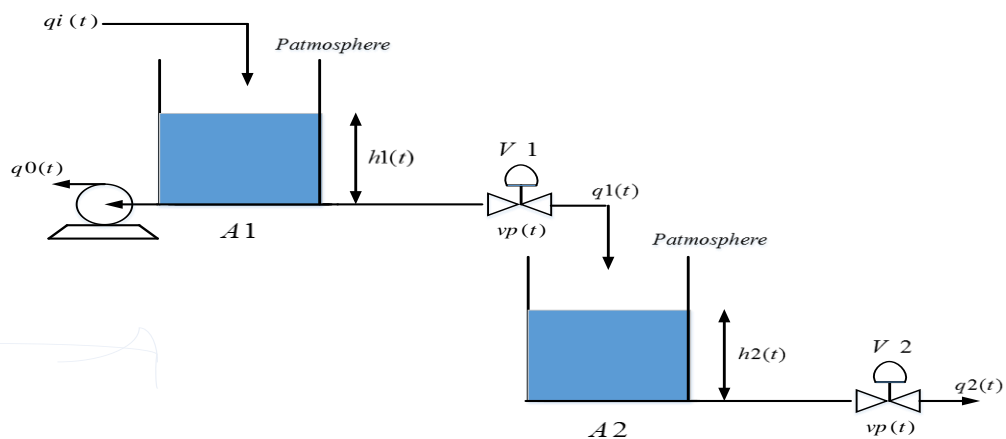


Fig. 3. Two tank system

By the process of inlets and outlets, level of the water is measured by scale and rotometer measures liquid flow through pipe by the control valves. Fig. 3 represents the schematic representation of two tank system. Where, q^i and q^0 represents inlet volumetric flow rate, q^2 represents Outlet volumetric flow rate, h represents height of liquid in the tank, V represents valve coefficient, A represents cross sectional area of the tank.

6.3 Multi water tank system

Multi tank system is comprised by number of separate tanks are connected together by means of drain valves. The system introduces nonlinearities and the upper tank is filled by speed pump. Each level in the tank is connected by sensors for reaching the stabilized level in the tank. Many state variables in the multi-dimensional control creates complex dynamic system. The limitations in the control system is solved by the ranging strategies of PIF and adaptive Fuzzy logic. The inlet and outlet flow of water is controlled by the operand is MATLAB/Simulink environment [38].

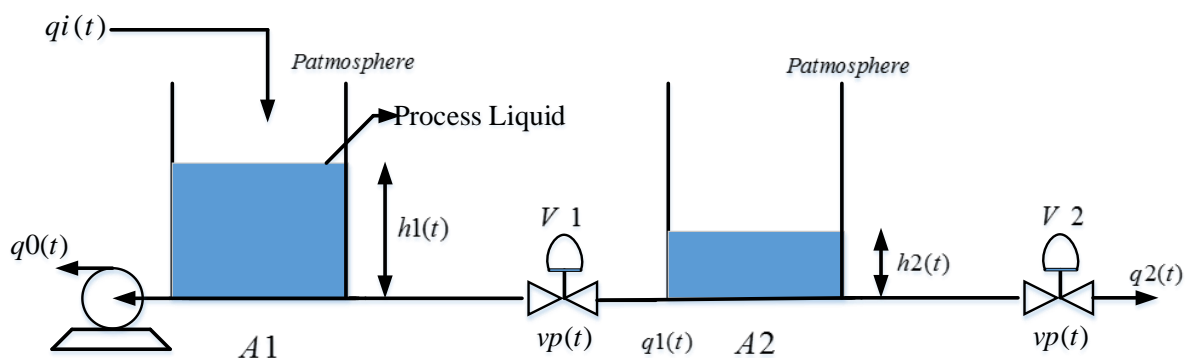


Fig. 4. Multi tank system

Fig. 4 represents the schematic representation of multi tank system. Where, q^i and q^0 represents inlet volumetric flow rate, q^2 represents Outlet volumetric flow rate, h represents height of liquid in the tank, V represents valve coefficient, A represents cross sectional area of the tank.

7. REVIEW BASED ON SINGLE TANK DYNAMIC SYSTEM

Bentoet *al.* [39] have introduced to measure the real time capacitive for the measurement of liquid level. Parallel R-C circuit was used to convert voltage variation into level variation for getting good accuracy. Different salt concentration in the liquid does not affects sensor operation because the analog and microcontroller made the sensing process more dynamic are used to measure liquid in the tank.

Shenget *al.* [40] have developed a technique to control the water level in the tank by the PID controller through Arduino Mega 2560. Arduino plays a good performance in collecting data and controlling the external algorithm in the real time implementation. PMW controls the motor speed and the rate of flow into the tank for every 11 seconds. Thus, the motor speed decreases until the system reach the set point.

Cuiet *al.* [41] have developed a water level measurement and control method based on programmable Logic Controller (PLC). The system of closed loop is formed by the Variable Frequency Drive (VFD) and sensors. The system improves the application performance and achieves remote monitoring by the large scale application of PLC.

Pratamaet *al.* [42] have developed gain scheduling PID with the back calculation integrator anti-windup for controlling water level in the tank. The system performance by various set point was performed by the gain scheduling PID controller. Water tank level was measured by the PING Parallax ultrasonic sensor having the range of 3-200 cm. The water pump of PMW was driven by the combination of Arduino UNO and motor driver

L298P. From the overall response of the developed system, author concludes that the system response of gain scheduling PID is better than the Conventional PID.

Patelet *al.* [43] have introduced a method of Fault Tolerant Control (FTC) strategy in the single tank system by Fuzzy logic. To control the leakage and the level of water in the tank is established by Passive Fault Tolerant Control (PFTC) and compared this strategy with Fuzzy logic plus PI control and PFTC strategy using conventional PI feedback controller. PFTC technique is developed to control leak fault in the single tank system and is simulated by the MATLAB/Simulink environment. The PFTC technique comprises of two schemes, one is PI feedback controller and the other is Fuzzy logic plus PI feedback controller. Having two techniques path selection in PFTC have better performance in different magnitudes. Table 1 represents the analysis of single tank dynamic system.

Table 1: Analysis of single tank dynamic system

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Bentoet <i>al.</i> [39]	Parallel R-C circuit	To develop a real time capacitive sensor to measure liquid level in the tank.	Simple maintenance, easy installation, good accuracy.	Sensor operation needs improvement to eliminate the salt concentration in the liquid.	Different concentration in the liquid does not affects the sensor operation
Shenget <i>al.</i> [40]	PID controller based on Arduino Mega 2560	To maintain the water level in the tank by Arduino.	Monitor and maintain water level.	Requires advanced methods to improve its performance.	Maintain water level.
Cuiet <i>al.</i> [41]	PLC	Control and measure water level in the tank by PLC.	The process can monitor by the host computer.	Performance is reduced by fault calculation.	In real time water level is detect accurately.
Pratamaet <i>al.</i> [42]	Gain scheduling PID with anti-windup	To control water level in the tank by Gain scheduling PID with anti-windup	Fast raise in time and settling time.	Produce noise in the real implementation.	Anti-windup has the raise in time of 34.6 second.
Patelet <i>al.</i> [43]	PFTC	Control water level in the tank by PFTC technique.	The technique can achieve set point effectively even in the different magnitude.	Multiple faults are not reduced.	Have better performance in different magnitude.

8. REVIEW BASED ON TWO TANK DYNAMIC SYSTEM

Grega *et al.* [44] have introduced co-design method to reduce the sampling period and regulates the variable time delay. Co-design method controls the stabilisation problem in the liquid level by introducing buffer length for increasing the robustness in Networked Control System (NCS). The delay in the loop variability was

reduced by buffer on the side of actuator. Co-design method was developed by the tendencies of long and the short buffers increases the quality of the distributed control system.

Xuet *al.* [45] have developed a closed loop system in Two Tank Liquid Level System (TLLS) by Port-Controlled Hamiltonian (PCH) to reduce the unmeasurable parameters and to control the disturbance. TLLS achieves a better performance by utilizing the property of PCH method and the adaptive measures in the attenuation technology. The computational complexity is reduced by the construction of Hamiltonian function. It reduces the lumped disturbance, good robustness and the ability to reject disturbance.

Osadchyyet *al.* [46] have introduced a method for increasing the quality of automatic monitoring and controlling activity of two tank dynamic system. The MIL-127 microprocessor controller was used to control liquid level in the tank. Matlab/Simulink software was used to monitor the steady state and the delay of the signal for the on-off function of the valve. This developed technique have better efficiency in decreasing the complexity and increasing the performance to control water level in the tank.

Puralachettyet *al.* [47] have developed the technique of Two System Initialization (TSI) was used to initialize Differential Evolution (DE) with Particle Swarm Optimization (PSO). To monitor liquid level in the coupled tank system was controlled by PSO algorithm to tune PID controller. The flow of liquid in the tank is adjusted by the valve and it was controlled by PID controller. This technique achieves better robustness and the dynamic behaviour of the water tank.

Ruizet *al.* [48] have implement a multi variable process of two tank system by Internal Model Control (IMC) based PID controller. The process of monitor and control are analysed by the tuning of PID controller in the control system. The interaction between the controlled systems was iterated by means of decoupling techniques to design in a simple way. To enhance Multi Input Multi Output (MIMO) by the learning process for controlling and the decouplers design to tune PID by IMC technique.

Bhaskarwaret *al.* [49] have introduced 4.0 revolution to monitor the coupled tank and it was regulated by PLC-OPC-MATLAB method. The coupled tank level was achieved by primary and secondary loops by minimum settling time in the configuration of Proportional Integral derivative-Proportional (PID-P) strategy. Remote monitoring process was done by the ThinkSpeak server for the observation of water level. OPC connection in the PLC and MATLAB have obtained 1 m sec efficiency in sampling time.

Ma *et al.* [50] have introduced a Lyapunov function in the two tank system to control the sliding mode in the discrete time. To minimize the frequency in control system, the author have developed a chattering free linear discrete system. In the practical system it can save much amount of energy and control the liquid level in the tank by chattering free method. The stable level in the system and feasibility are controlled by the chattering free method and having good sliding mode and reduces energy conservation.

Renet *al.* [51] have developed a technique of Conditional Integral Sliding Mode Variable Structure Control (CISMC) to control the level in two tank system for solving the transient degradation performance. Conditional Integrator (CI) was introduced in the method to decrease the chattering and increasing tracking accuracy with transient performance. The act of CI was only in the boundary layer and it creases the performance of transient by conventional ISMC.

Esmaeili *et al.* [52] have developed a technique to control the vertical nonlinear coupled system by linear matrix Inequalities (LMI) based H_2 to decrease the robustness and increasing the accuracy for the liquid level in the tank. To overcome the difficulties in the design procedure, LMI was used. The disturbance in the rejection and the noise error are minimized by H_2 controller and have optimal control in the tracking of signal.

Hindy *et al.* [53] have developed to improve SIEM for critical water infrastructure of Supervisory Control and Data Acquisition (SCADA) using Machine Learning (ML). The anomaly detection in the system was carry out by SCADA and PLC was used for the network monitoring and controlling. The technique have better performance and achieves the accuracy of 94% and 95.64% for the scenario classification. Table 2 represents the analysis of two tank dynamic system.

Table 2: Analysis of two tank dynamic system

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Gregoetal. [44]	Co-design	Increasing robustness in NCS by introducing buffer.	Any delay compensation method can be used.	The performance in offline is low.	Easily implement for automation purpose.
Xueta. [45]	TTLs by PCH	To eliminate the disturbance in two tank liquid level system by Hamiltonian.	Ability to reject disturbance and good robustness	PCH technique is not support for multi-tank liquid level system.	The fluctuations in the two tanks not affects each other.
Osadchyyeta. [46]	MIL-127	Monitoring liquid level by microprocessor control system.	It controls water level in the tank and decrease complexity.	This technique is not possible in signal variation.	Reduces the complexity in real time applications.
Puralachettyeta. [47]	TSI by DE-PSO	DE and PSO algorithm tuned the coupled tank by PID controller	Provide better robustness and dynamic behaviour of tank.	Not possible in offline mode.	This technique is applicable in real time.
Ruizeta. [48]	IMC based PID controller	Design decouplers to tune PID by IMC technique	It reduces the effect of interaction and ties independently.	Complex implementation	Have better iteration in controlling process.
Bhaskarwareta. [49]	PLC-OPC-MATLAB	Remote monitoring of coupled tank by OPC connection in the PLC and MATLAB	The connections of this technique is fast.	This technique is not possible in offline mode	It provides sampling time of 1 msec.
Ma eta. [50]	Lyapunov function	Control the discrete time sliding mode in the two tank system	Provide good performance and better sliding mode.	This technique is only applicable for two tank system	Have better performance in sliding mode.

Renetal. [51]	CISMC	Solving transient degradation performance by CI.	Tracking accuracy is increased and chattering is reduced	Cause deviation in levelling process.	Control of chattering up to 1.1845e-4
Esmaeilietal. [52]	LMI based H ₂	To control vertical nonlinear coupled system by LMI based H ₂ .	The disturbance rejection is controlled by H ₂ and increases the tracking signal.	This technique suffer to eliminate the errors.	Tracking error – 9-15% and control signal – 68-142%
Hindyetal. [53]	Machine Learning	Improving SIEM for critical SCADA infrastructure by ML	Achieves high accuracy and scenario classification.	Due to complex in architecture, it is not applicable for multi tank system	Accuracy - 94% and scenario classification- 95.64%

9. REVIEW BASED ON MULTI TANK DYNAMIC SYSTEM

Możarynet *al.* [54] have developed a methodology to reduce the complexity and gain high performance by designing PLC based Industrial Internet of Things (IIoT). The unknown input in the tank is detected and controlled by the implementation of FDI module in the PLC controller to isolate simulation in the sensor. It reduce the impacts that cause damage to the operating system and improves the process by managing the entire plant in the industrial concept of 4.0.

Son *et al.* [55] have introduced Adaptive Inverse Evolutionary Neural (AIEN) controller used to control the liquid level in the multi (quadruple) tank system. The hybrid of modified differential evolution and back propagation algorithm can optimize the three layers in the evolutionary neural model. The evolved technique was developed to work in online and it is reduces the time consumption by controlling the quadruple tank level.

Martinezet *al.* [56] have developed a Multi- Critic Reinforcement Learning (multi-critic RL) Method by the combination of Reinforcement Learning (RL) and neural networks for multi tank dynamic system. The flow of water in the open channel was controlled and minimize the error by filtered multi-critic Deep Deterministic Policy Gradient (FMCDDPG). The training is performance is improved by the multi-critic scheme and reduces the complexity as compared to single-critic method.

Hedreaet *al.* [57] have developed a cascade Control System (CCS) for multi tank by PID-State Feedback Control System (PID-SFCS) and PID-Tensor Product based Control System (PID-TPCS) for inner and outer loop. The technique of PID based SFCS and TPCS ensures small settling time and zero steady state error in the multi tank system.

Babaieet *al.* [58] have developed a Sliding Mode Controller (SMC) based on Lagrange multipliers Optimization algorithm to control the level in three tank system. The height was adjusted in nonlinear three tank system by two inputs and one output. Fast and routine approach of Lagrange based multipliers are uses to find the local maxima and minima in the function. By the Optimization algorithm gained controller efficiency in Lagrange multipliers but failed to achieve an optimum condition by error method.

Bayramet *al.* [59] have introduced a technique to control the liquid level in the tank by simulator method using fuzzy control. The liquid level is monitored by the online connection of MATLAB/Simulink program and it was used for computation and data processing. Fuzzy algorithm provides better fluid level control under same conditions, more reliable and continuous operation.

Liu *et al.* [60] have developed moving window independent component analysis method with adaptive threshold (MWAT-ICA) for the fault alarm detection in three tanksystem. The technique of adaptive threshold is appliedto reduce the performance of false alarm and increases the process of false deduction.

Yanget *al.* [61] have developed to control robustness in the three tank system using finite time disturbance. The output of the three tank system is tracked by the robust controller of Finite Time DOB (FTDOB). FTDOBs enhance the virtual level and compensate the disturbance level in the output. DSC adapts the virtual technique and reduce the error signal.

Parikhet *al.* [62]have introduced a comparison technique of Linear Quadratic Gaussian Control (LQG) and Non-linear Model Predictive Control (NMPC) in the three tank system to achieve disturbance rejection and changing the valve position of the disturbance input. In the existence of artificial disturbance, the techniques of LQG and NMPC have set point tracking and regulatory control. By the comparison techniques, the author have concluded NMPC is the better choice for the interacting process in the three tank system.

Mrugalskiet *al.* [63]have developed a method to diagnose the fault detection in the nonlinear multi tank system by the technique of recurrent neural networks. Discrete time polytropic model LPV model is developed for the transformation of neural networks. The actuators achieve the disturbance attenuation level with zero fault by the Robust Neural Network-based False Estimator (RNNFE) method for the satisfactory accuracy. Table 3 represents the analysis of multi tank system.

Table 3: Analysis of multi tank dynamic system

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Możarynet <i>al.</i> [54]	PLC based on IIOT	To reduce the fault deduction by PLC technique	Damages in the operating system is reduced.	Estimating the algorithm cause damage in the operating system.	Detect and isolate the failures in operating system.
Son <i>et al.</i> [55]	AIEN	Monitor and control liquid level in the quadruple tank system.	Reduces time consumption and minimize the error by PID controller.	Not support for offline mode.	In online, error is reduced nearly zero.
Martinezet <i>al.</i> [56]	multi-critic RL and FMCDDPG	Reduce the complexity in single-critic method by RL and neural networks	Achieves better controller and zero steady state error	Multi-critic method need improvement in data efficiency for online training implementation.	Tracking error is reduced up to zero level
Hedrea <i>et al.</i> [57]	PID based SFCS and TPCS	Control the level in multi tank system by CCS scheme.	Small settling time.	CCS suffers from parametric sensitivity, robustness and stability in targeting.	Zero steady state error.
Babaieet <i>al.</i> [58]	SMC by Lagrange multipliers	To control level in three tank system by sliding	Increases the controller efficiency.	Failed to achieve an optimum condition by error method.	Better performance to control water level.

		mode controller.			
Bayramet al. [59]	Fuzzy Control	Control liquid level in the tank by simulation method.	Fuzzy Control performs better in nonlinear condition.	Complex in architecture.	Liquid level is controlled at the desired set point.
Liu et al. [60]	MWAT-ICA	To detect and reduce false detection in three tank dynamic system.	Gradual faults are detect on time.	Not possible in offline mode.	Detect and reduce false alarm rates by adaptive threshold.
Yanget al. [61]	FTDOB	Control robustness in three tank system.	Reduce error signal.	Requires electric servo motor to speed up the process.	Tracking performance is very well.
Parikhet al. [62]	LQG and NMPC	Determine the level of water tank by interacting method.	NMPC performs better in the interacting process.	LQG leads to chattering and damage the actuator	LQG and NMPC have better performance in set point tracking and regulatory control.
Mrugalskiet al. [63]	RNNFE	Diagnose the fault detection in the non-linear multi tank system.	UIO designed to estimate the fault estimation error.	Occurs steady state error.	Fault is estimated relatively zero error.

10. ANALYSIS OF METHODOLOGY AND CHALLENGES

The challenges and the future works are analysed on the basis of dynamic water tank control system and the enhancement of future scope. In the recent days, industries facing more issues in control and management of water level in the tank. Moreover, IoT techniques involved in water level management system to monitor and control the flow of water inside the tank in many areas. In some cases, IoT techniques are used to control liquid level are proved experimentally and also these techniques are succeed with and without the help of man power. But the techniques face challenges in the real time implementation of programs and cause deviations in measuring process. Fig. 5 represents industrial automation challenges in water level control system.

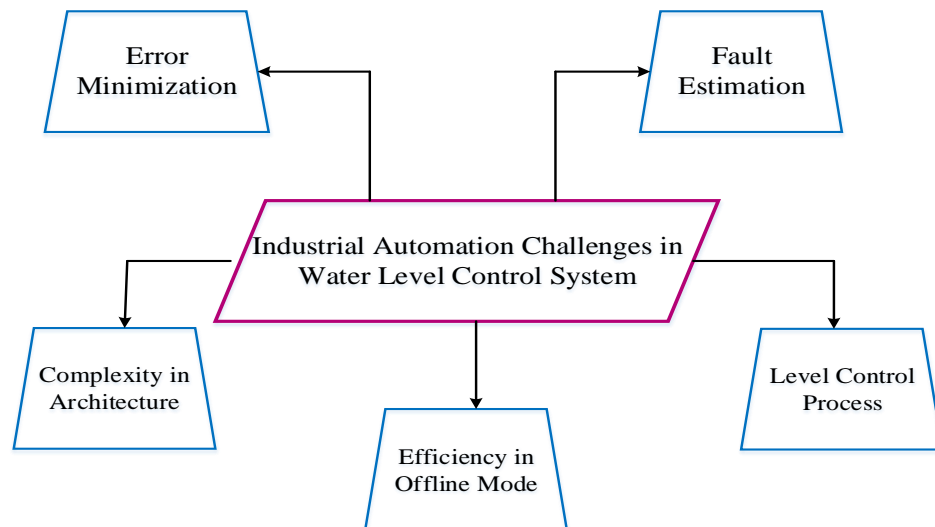


Fig. 5. Industrial automation challenges in water level control system

10.1 Liquid level control

- The existence of development gap in the control system for increasing the liquid level control process.
- Highly flexible distributed approach in SCADA cause complexity in controlling process.
- Critical SCADA cause complex in architecture and requires servo motors for speed up the process.

10.2 Efficiency in offline mode

- Wireless monitoring of control system cause fault detection when the process in offline mode.
- Many researches highlights the efficiency of level control in the offline mode but still the developed techniques face challenges while monitoring.
- In some cases, PCH techniques are not support for multi tank system.
- Estimation algorithm cause damage in the operating system.
- LQG technique in the control system cause damage in the actuators.

10.3 Reduce fault estimation and error minimization

- Fault estimation in the tank may cause irregular operation in the automatic on-off pumps and leads to overflow or under flow of water.
- Even in single variation in the control system cause irregular operation in the control process.
- In some embedded techniques, error methods failed to achieve optimum condition, robustness and stability in targeting.

11. CONCLUSION

The quick development of control methods to control water level in the tank by introducing new technologies based on IOT. The aim of this contribution is to monitor and control of water level by the simulation of MATLAB/Simulink environments. These are the techniques that are commonly exploited in the dynamic system and the designs are virtually realized by control systems. Every modern techniques includes sensors for monitoring and controlling the water tank level has its own realization by involving monitoring the filling level of water. These techniques are controlled by the techniques of PLC, SCHEMA and PID controllers and have large and diverse set of applications are developed to limits the challenges in industrial automation control techniques. Wireless technologies are developed in the industries for minimizing the wired schemes, fault estimation, error control and easy maintenance. Fuzzy technologies are better than the PID controllers and acquires cost efficiency, precise and reduce energy consumption.

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