Monitoring the Clarity of Swimming Pool Water Based on Fuzzy Decition Tree Algorithm

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Abstract—Swimming pool water turbidity is usually overcome by 2 ways namely draining and administration of chlorine. Draining or administration of chlorine is not efficient because it needs a specified schedule and cannot be done outside the schedule, specifically for draining, when there are many visitors. The water turbidity needs to be monitored and detected to maintain water quality in the swimming pool. This monitoring tool is designed with a light sensor and its transmitter processed by using an AT89C51 type microcontroller based on Fuzzy Decision Tree Algorithm and an LCD. What is measured in this device is the strength of the light intensity when the lamp is blocked by water. This device is useful for knowing the right time to replace the pool water. The device was proven able to detect turbidity of the pool water. It can identify three pond water conditions namely; clear, medium and cloudy indicating the right the time to replace the pool water.

Keywords—water turbidity, light sensor, microcontroller, AT89C52, Fuzzy Decision Tree Algorithm

Introduction

Swimming pool facilities, quality and service greatly affect the business of the field. One of the services that shall be concerned is the level of cleanliness of the pool water. The term clean water in this case is categorized as feasible for consumption, not for supporting activities such as for bathing or washing because the standard of water used for consumption is clearly higher than for other purposes. There are several requirements for good quality of the water both physically, chemically and also microbiology. Physical requirements expect that the water must be clean, clear and not cloudy, colorless, tasteless, no smell, temperatures between 10-25oC, and does not leave deposits. Chemical requirements expect that the water do not contain toxins, do not contain excessive chemicals, has sufficient iodine and pH between 6.5 - 9.2. Based on the results of the author's observation on several swimming pools, almost every swimming pool does not have a device that can measure the turbidity level of the water. With the presence of turbidity detection device, chlorine administration can be done at the right time when the water turbidity has reached the predetermined level. Thus, the water clarity of the swimming pool is maintained well.

Based on those facts, a system to detect and monitor the level of turbidity of the pool was created. Some of the previous researchers have conducted research on detection of water turbidity including research on a smart sensor device for detection of water quality in anticipation of environmental pollution of the disaster carried out by Taufiqurrahman. The system was designed using six sensors consisting of temperature sensors, water temperature sensor, pH, TDS, turbidity, and water level. The sensor reading system used was an ATMEGA2560 microcontroller and the data were displayed on an LCD. Algorithm Fuzzy logic detected the water quality. The system detected the water quality [1]. Hu carried out research on detection of multi-parameter water quality in seawater based on UV-Vis spectrometry. The system consisted of sensors to detect chemicals such as NO3, chemical oxygen demand (COD), and total organic carbon (TOC). The system used visible spectrum to detect water colors, turbidity, and total suspended solids (TSS). The system can detect water quality by using partial least squares (PLS) algorithm [2].

Wang examined underwater electro sensory membranes inspired by weak electric fish. The system used membrane sensors processed using the Kalman filter algorithm. The back-propagation neural network algorithm and Kalman filter processed the membrane sensor data. Membrane sensors navigated fish in turbid water [3]. Karnawat examined turbidity detection using image processing. The camera sensor used in the system detected the water turbidity. The histogram algorithm used in image processing clarified the images obtained. The algorithm could detect the quality of water turbidity [4].

Benalcazar designed of electronic devices for turbidity detection in blood serum in newborns. The system consisted of photodiode sensors, signal conditioners, microcontrollers and displays. The system created could detect turbidity in blood serum in newborns [5]. Pan combined LiDAR in Orthowave form and Hyperspectral Imagery for River Bathymetry and turbidity estimation. The system consisted of lidar sensors processed using algorithms with support vector regression (SVR) method. The algorithm of support vector regression and Lidar sensors could detect water turbidity [6].

A new method for assessing high-quality underwater images was investigated by Lu. The system consisted of camera sensors, a computer using four inter core i7, and robust computer vision algorithms. The contrast enhancement method of the image was

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proposed by using a robust computer vision algorithm to improve the image of turbid water quality [7]. Ultrasonic sensors used for monitoring particles in liquids were examined by Johansen. The system consisted of ultrasonic sensors used to measure particles in a liquid. The sensor could detect turbidity of liquid when the particles in the liquid were close together [8]. Wang conducted research on low cost turbidity sensors for low power wireless monitoring for freshwater programs. The system consisted of an infrared sensor and a dual orthogonal photodetector connected to the conditioning signal and displayed on a computer. The system could identify water turbidity using the voltage values obtained from the sensor readings [9]. Kirkey designed low cost turbidity sensors using low frequency light source modulation. The low frequency around 50 - 60 hz was used by the system to turn on the LED. An optical sensor in the form of a photodiode sensor detected water turbidity. Condition signals processed the data and then read by ADC to find out the water turbidity level [10].

TOC Sensors Ultraviolet absorption was investigated by Fu. The system consisted of light sensors, signal conditioners and microcontrollers. Signal conditioning signal eliminated noise by using a low pass filter and amplified the signal using amplifier. The conditioning signal used PID algorithm to get the optimal output signal so that the system could detect water turbidity [11]. Lokuliyana used IoT for measuring and distributing water quality. The system consisted of pH sensor, turbidity sensor and temperature sensor. The sensors were connected to Arduino then displayed on the LCD. The neural network algorithm modified into the Recurrent Neural Network (RNN) algorithm was used to predict water quality [12]. Underwater LiDAR signal processing to improve detection and localization of marine life was examined by Dubrovinskaya. The system consisted of Lidar sensor, digital processing signal and game filtering algorithm. Sea turbidity could be investigated by using this system [13]. Joslyn studied support vector regression method to detect water turbidity. Water quality parameters such as dissolved oxygen and turbidity play an important role in policy decisions regarding the maintenance and use of the country's main water bodies [14]. Hu designed intelligent detection of lateral lines by bio-inspired robotic fish using EMDs and SVMs. The system used an optical sensor to detect water turbidity. The support vector mechine algorithm made detection systems accurate [15].

Kim examined the performance of underwater laser communication in turbid water. The system consisted of laser, photodiode, Arduino, analog digital converter, and PC. Green laser was used because water turbidity could not absorb it. The modulation algorithm was used to create the frequency of transmitting a laser beam. By using this system, the performance of laser communication in turbid water could be optimized [16]. Devi demonstrated intelligent water quality monitoring system using wireless sensor networks. The system consisted of a pH sensor, turbidity sensors and temperature sensors. An MSP432P401 type Microcontroller processed the sensor data and then broadcasted them to GPRS using the GPRS module. The comparison algorithm detected turbid water [17]. Rojas investigated monitoring system for error detection and diagnosis in drinking water treatment plants using Fuzzy machines. The system consisted of turbidity sensors and fuzzy logic algorithms to process data from the sensors [18]. Gopavanitha investigated Low-cost systems for monitoring and controlling real-time water quality using IoT. The system consisted of five sensors namely temperature, turbidity, conductivity, pH and flow sensors. The sensor data were processed using raspberries and then broadcasted to clouds using Wi Fi. This system only monitored those using internet facilities [19].

Many researchers have conducted research on turbidity detection using a combination of algorithms and optical sensors. The algorithms used were the comparison algorithm, partial least squares, neural network, and fuzzy logic controller. Optical sensors were used to detect turbidity of water. The optical sensor presented in this paper used photodiode sensors and laser sensors. This system is different from the previous warning system this system uses fuzzy decision tree algorithm to detect turbidity of water.

RESEARCH METHOD

The research model is a microcontroller-based swimming pool water clarity monitoring system design that can be used either automatically or manually according to pool users or administrators. The design of the device consisted of two parts namely the design of hardware and the design of software that control and determine the right time to replace the water.

Hardware design

The overall circuit is a combination of subsystems as shown in figure 1. The figure illustrates that the working system of the device in general is the intensity of the incoming light which will be changed by the LDR (light depending resistor) sensor from physics into analog electricity, and the analog voltage will be converted to digital voltage by the ADC, then displayed on the LCD [20], [21].

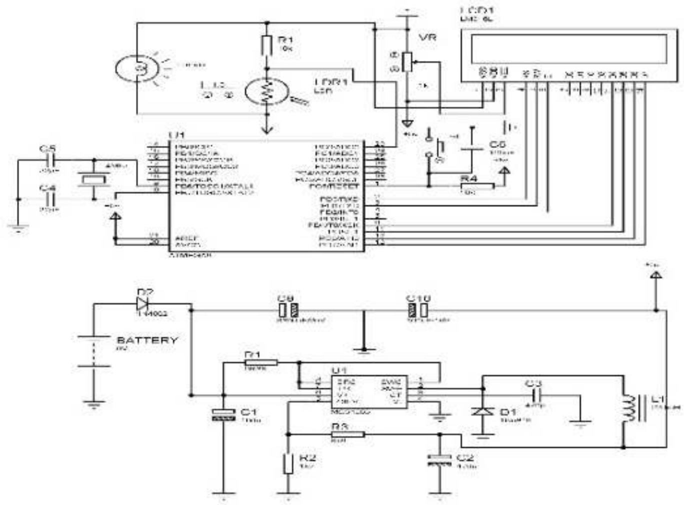

Fig. 1. Design of hardware cabling

Software design

The software for this system is built in C language and uses CodeVisionAVR Standard as its compiler with shown in figure 2. It can be seen in the figure that when the system is turned on, the microcontroller will start the program from the initialization until it is displayed on the LCD [22], [23]. The sequence of the work after turned on is shown by the direction of the arrow in figure 2. In this process, all library components used are initialized and checked. After the initialization process is completed, the sensor is read and the sensor voltage is converted to digital.

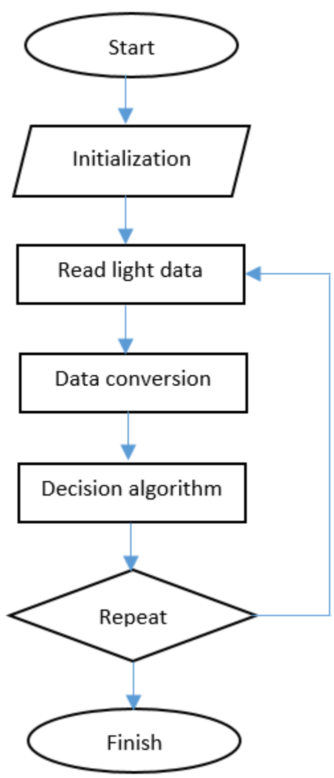

Fig. 2. Workflow diagram of the system.

When the conversion has been completed, the data were then displayed on the LCD and this process continued. Figure 3 displays decision-making algorithm using the Fuzzy Decision Tree method[24]–[28]. The figure shows three roots used for decision makers. The first decision-making tree root has a value of more than 8000 lux used for a clear water indicator. The second

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decision-making tree root has values ranging from 6980 to 8000 lux used for medium turbid indicator. The third decision-making tree root has a value of less than 6980 lux used for turbid indicator.

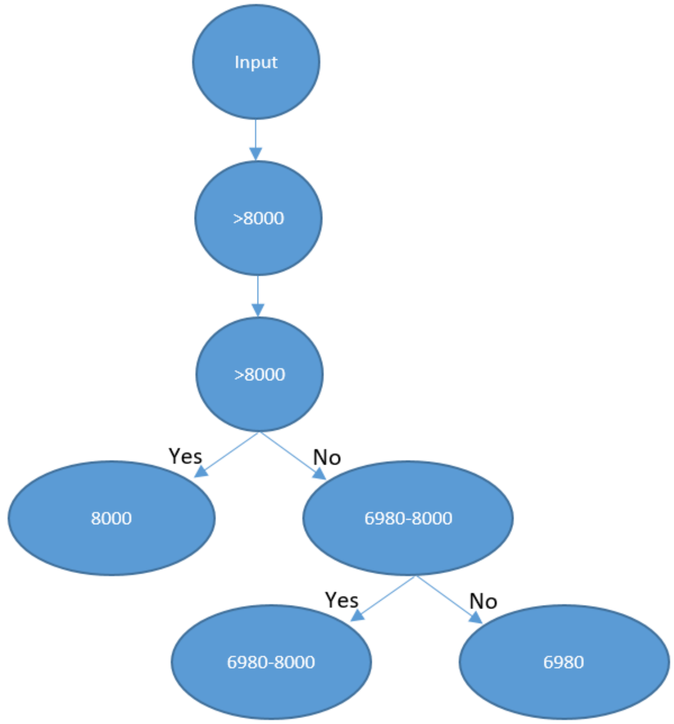

Fig. 3. Fuzzy Decision Tree method.

Results and Analysis

The device system used a switch for its power supply regulator so that to produce a stable voltage of 5V, the coil had to be 220 uH + -3%. The magnitude of the resistance value of the LDR was inversely proportional to the amount of light entering the LDR, therefore, the LDR sensor circuit was mounted with a 150 Ohm resistor that had to be connected to the ground. The reference voltage of the ADC was 5V because at the VREF the microcontroller had to be connected to a voltage of 5V. The ATMega8 microcontroller required a supply voltage of 4.5-5.5V so that to fulfill that, a switch that produced a stable output voltage of 5 V was mounted. The ADC used for this tool was 10 bits.

To implement the device in the actual conditions it is necessary to test the performance of the measurement or detection of the sensor and the testing of the whole device.

LDR sensor testing

The sensor used is the LDR sensor. The test results are shown in Table 1.

TABLE I. Data on LDR sensor test results

Luxmeter readings	Resistor	Volt
19.999	100 ohm	2.97 V
10.000	154 ohm	2.44 V
1000	500 ohm	1.14 V
100	2400 ohm	291 mV
30	6500 ohm	111 mV
10	16.000 ohm	45 mV
1	130 k ohm	5.7 mV

So the higher the luxmeter value, the smaller the LDR and V output resistance. This indicates that the LDR sensor is functioning properly.

Overall tool testing

This test involves the entire series that has been designed. The microntroller circuit testing is a test of all the functions that exist in the series that have been integrated in a complete circuit, including LCD testing, sensor testing and power. The results of the test on the whole system can be seen in Table 2.

TABLE II. RESULTS OF SUBSYSTEM TEST

No.	Tool	Condition	Work Description	Status
1	Reset Switch	OFF	Normal	OK
		ON	Resetting mikrokontroller and repeating program operation (restart)	OK
2	LDR Sensor	Light Intensity increases	Resistor is getting smaller	OK
		Light Intensity decreases	Resistor is getting higher	OK
3	Display		Displaying the data according to what is commanded by the program	OK
4	Voltage Series		Voltage output ~5v	OK
5	Indicator		Indicator on/off in accordance with the condition of connected or disconnected power	OK

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CONCLUSION

Referring to the results of the design and testing of the device, it was concluded that by using the swimming pool water turbidity monitoring device, the pool water turbidity can be detected. The clear limit is when the light intensity entering the sensor is greater than 8000 lux. The medium limit is when the light intensity entering the sensor is between 6980 - 8000 lux, while cloudy limit is when the light intensity entering the sensor is less than 6980 lux. By using a swimming pool water turbidity detector, the right time to replace the pool water can be determined. The test results showed that changes in the water turbidity affect the output voltage generated. The more turbid the water, the smaller the output voltage.

REFERENCES

[1] Taufiqurrahman, N. Tamami, D. A. Putra, and T. Harsono, “Smart sensor device for detection of water quality as anticipation of disaster environment pollution,” in 2016 International Electronics Symposium (IES), 2016, pp. 87–92.

[2] Y. Hu, Y. Wen, and X. Wang, “Detection of water quality multi-parameters in seawater based on UV-Vis spectrometry,” in OCEANS 2016 - Shanghai, 2016, pp. 1–4.

[3] K. Wang, L. Cui, and K. D. Do, “An underwater electrosensory membrane bio-inspired by weakly electric fish,” in 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2016, vol. 2016-Novem, pp. 4951–4956.

[4] V. Karnawat and S. L. Patil, “Turbidity detection using image processing,” in 2016 International Conference on Computing, Communication and Automation (ICCCA), 2016, pp. 1086–1089.

[5] D. Benalcazar, L. Eguiguren, M. B. Alvarez, E. Arteaga, F. Jacome, and M. Grunauer, “Design of an electronic device for turbidity detection in blood serum in newborns,” in 2016 IEEE Ecuador Technical Chapters Meeting (ETCM), 2016, pp. 1–4.

[6] Z. Pan, C. L. Glennie, J. C. Fernandez-Diaz, C. J. Legleiter, and B. Overstreet, “Fusion of LiDAR Orthowaveforms and Hyperspectral Imagery for Shallow River Bathymetry and Turbidity Estimation,” IEEE Trans. Geosci. Remote Sens., vol. 54, no. 7, pp. 4165–4177, Jul. 2016.

[7] H. Lu et al., “A Novel High-Turbidity Underwater Image Quality Assessment Method,” in 2016 International Symposium on Computer, Consumer and Control (IS3C), 2016, pp. 34–36.

[8] R. Johansen et al., “An In-Line, High-Flowrate, and Maintenance Free Ultrasonic Sensor With a High Dynamic Range for Particle Monitoring in Fluids,” IEEE Sens. J., vol. 18, no. 6, pp. 2299–2304, Mar. 2018.

[9] Y. Wang, S. M. S. M. Rajib, C. Collins, and B. Grieve, “Low-Cost Turbidity Sensor for Low-Power Wireless Monitoring of Fresh-Water Courses,” IEEE Sens. J., vol. 18, no. 11, pp. 4689–4696, Jun. 2018.

[10] W. D. Kirkey, J. S. Bonner, and C. B. Fuller, “Low-Cost Submersible Turbidity Sensors Using Low-Frequency Source Light Modulation,” IEEE Sens. J., vol. 18, no. 22, pp. 9151–9162, Nov. 2018.

[11] S. Fu, L. Chen, H. Huang, and X. Zhang, “An Ultraviolet Absorption TOC Sensor,” in 2018 2nd IEEE Advanced Information Management,Communicates,Electronic and Automation Control Conference (IMCEC), 2018, no. Imcec, pp. 1416–1419.

Corresponding Author: Iswanto, Email: 1iswanto_te@umy.ac.id
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[12] S. Lokuliyana, A. Jayakody, N. B. R. P. Bandara, J. W. P. Deshapriya, P. . Kavinda, and T. . Wijewickrema, "A Survey: IoT Enable Framework for Water Quality Measurement and Distribution," in 2018 13th International Conference on Computer Science & Education (ICCSE), 2018, no. Iccse, pp. 1–6.
[13] E. Dubrovinskaya, F. Dalgleish, B. Ouyang, and P. Casari, "Underwater LiDAR Signal Processing for Enhanced Detection and Localization of Marine Life," in 2018 OCEANS - MTS/IEEE Kobe Techno-Oceans (OTO), 2018, pp. 1–8.
[14] K. Joslyn and J. Lipor, "A Supervised Learning Approach to Water Quality Parameter Prediction and Fault Detection," in 2018 IEEE International Conference on Big Data (Big Data), 2018, pp. 2511–2514.
[15] Q. Hu, Y. Liu, Z. Y. Zhao, and Z. F. Lei, "Intelligent Detection for Artificial Lateral Line of Bio-Inspired Robotic Fish Using EMD and SVMs," in 2018 IEEE International Conference on Robotics and Biomimetics (ROBIO), 2018, pp. 106–111.
[16] S.-R. Kim, T.-W. Kang, K.-M. Kim, and D.-H. Lee, "Performance of Underwater Laser Communication in Turbid Water," in 2018 OCEANS - MTS/IEEE Kobe Techno-Oceans (OTO), 2018, pp. 1–4.
[17] L. N. Devi, G. K. Reddy, and A. N. Rao, "Live Demonstration on Smart Water Quality Monitoring System Using Wireless Sensor Networks," in 2018 IEEE SENSORS, 2018, vol. 2018-Octob, pp. 1–4.
[18] G. A. Rojas, E. L. Quiroga Rubiano, J. F. Caratar Chaux, C. R. Pinedo Jaramillo, and J. I. Garcia Melo, "Supervisory System for Fault Detection and Diagnosis in Drinking Water Treatment Plants Using Fuzzy Engine," IEEE Lat. Am. Trans., vol. 15, no. 11, pp. 2071–2076, Nov. 2017.
[19] K. Gopavanitha and S. Nagaraju, "A low cost system for real time water quality monitoring and controlling using IoT," in 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), 2017, pp. 3227–3229.
[20] Iswanto, J. Syaftriadi, A. Nur, N. Chamim, R. O. Wiyagi, and R. Syahputra, "LED and Servo Motor Control Via Bluetooth Based on Android Applications," Int. J. Recent Technol. Eng., vol. 8, no. 2, pp. 6227–6231, Jul. 2019.
[21] A. N. N. Chamim, M. E. Fawzi, R. O. Wiyagi, I. Iswanto, and R. Syahputra, "Control of Wheeled Robots with Bluetooth-Based Smartphones," Int. J. Recent Technol. Eng., vol. 8, no. 2, pp. 6244–6247, Jul. 2019.
[22] D. Hardiyanto, I. Iswanto, D. A. Sartika, and M. Rojali, "Pedestrian Crossing Safety System at Traffic Lights based on Decision Tree Algorithm," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 8, pp. 375–379, 2019.
[23] R. Mubarok, D. Verdy Firmansyah, D. Haryanto, N. Pratama Apriyanto, U. Mahmudah, and I. Iswanto, "Motorcycle-Security using Position Searching Algorithm Based on Hybrid Fuzzy-Dijkstra," Indones. J. Electr. Eng. Comput. Sci., vol. 3, no. 2, p. 468, Aug. 2016.
[24] Iswanto, K. Purwanto, W. Hastuti, A. Prabowo, and M. Y. Mustar, "Smart smoking area based on fuzzy decision tree algorithm," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 6, pp. 500–504, 2019.
[25] I. Iswanto, W. S. Agustiningsih, F. Mujaahid, R. Rohmansyah, and A. Budiman, "Accumulator Charging Control with Piezoelectric Based on Fuzzy Algorithm Scheduling," TELKOMNIKA (Telecommunication Comput. Electron. Control., vol. 16, no. 2, p. 635, Apr. 2018.
[26] A. N. N. Chamim, M. Heru Gustaman, N. M. Raharja, and I. Iswanto, "Uninterruptable Power Supply based on Switching Regulator and Modified Sine Wave," Int. J. Electr. Comput. Eng., vol. 7, no. 3, p. 1161, Jun. 2017.
[27] A. N. N. Chamim, D. Ahmadi, and Iswanto, "Atmega16 implementation as indicators of maximum speed," Int. J. Appl. Eng. Res., vol. 11, no. 15, pp. 8432–8435, 2016.
[28] K. Purwanto, I. -, T. Khristanto, and M. Yusvin, "Microcontroller-based RFID, GSM and GPS for Motorcycle Security System," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 3, pp. 447–451, 2019.