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Enhanced digital water level measurement for irrigation channel

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Abstract. Indonesia needs to improve its irrigation system by implementing respectable technology. Recently, Indonesian irrigation systems have intended to switch from analog to digital technology. However, it appeared that Indonesia was having some issues applying digital technology in many areas. For instance, delivering water from water sources to irrigation subversives requires a computer infrastructure. A manual water level monitoring tool has been used in irrigation canals to gauge the water level that flows through them. The major goal of this project is to design a digital measuring device for water level and water temperature in the irrigation channel. The appropriate information must be entered into the irrigation channels. An experimental investigation has been conducted into the accuracy of digital instrument design for detecting water level and water temperature in irrigation channels. The creation of the digital water level measurement design will be tested against manual measurement to determine the percentage difference. The percentage difference between the traditional water level measurement and the digital water level measurement is the anticipated outcome. It is possible to infer that it is crucial to use digital tools, especially when determining the water level in irrigation channels.

1. Introduction

One of the crucial tasks in civil engineering projects is building irrigation systems. The estimate of water availability and the construction of storage or reservoirs suited to the water balance should have allowed for the identification of the requirement for water for agriculture. Demands for irrigation have increased over time as a result of the growth and development of modern agriculture. Indonesia needs to improve its irrigation system by implementing respectable technology. Recently, Indonesian irrigation systems have intended to switch from analog to digital technology. However, it appeared that Indonesia was having some issues applying digital technology in many areas. For instance, delivering water from water sources to irrigation subversives requires a computer infrastructure. A manual water level monitoring tool has been used in irrigation canals to gauge the water level that flows through them. The major goal of this project is to design a digital measuring device for water level and water temperature in the irrigation channel. The appropriate information must be entered into the irrigation channels [1].

Through the provision of guaranteed irrigation water along with improved agricultural supporting services, diversification, soil conservation, drainage facilities, roads, and other facilities in the irrigation project area, the irrigation project seeks to increase agricultural production, particularly rice, to create employment opportunities, and to improve the living conditions of farmers [2].

The scope of the design work for the irrigation project will be limited to the precise design of each separate major irrigation system, including weirs, main and minor canals, and associated structures in the project area, respectively. A weir is a type of structure that is placed across a stream to direct water flow to irrigation areas by increasing the water level to maintain the necessary water height. The reservoir's purpose is to hold water, but the weir's role is to enable uninterrupted flow through the weir.

Basic studies should be carried out in order to plan and construct the weir and irrigation system in general. The primary information gathered is a topographic map, a stream profile, and a cross-section. The state of the water level can also be observed using stream flow data from gauging stations. The water level that flows through an irrigation channel was measured at this stage using a manual water level monitoring instrument. Water-saving agriculture refers to a farming practice that is able to take full advantage of the natural rainfall and irrigation facilities [3].

2. Literature review

Several parts and sensors were employed in the development of this water level monitoring instrument, among others, and will be discussed in this area of the literature review [4]. These elements and sensors play a significant role in the creation of tools. The outcomes of this study will be determined by the output findings generated by the sensors, processed by the microcontroller, and shown on a 2x16 LCD.

2.1. Microcontroller

In order to take input signals, process them, and then produce output signals in accordance with the program written into the microcontroller, it is a chip known as an IC (Integrated Circuit). This microcontroller receives its input signal via sensors that may collect data from its immediate surroundings. The actuator receives the output signal, which might have an impact on the surrounding area. In light of this, it can be said that a microcontroller may be compared to the brain of a machine or product that can communicate with its surroundings.

Because a microcontroller has a microprocessor, memory, input/output (I/O) lines, and other complementing devices on a single chip, it is also sometimes referred to as a computer. The microcontroller processes data at a significantly slower rate than a personal computer. While the working speed of the microcontroller typically runs from 1-16 MHz, the speed of the microprocessor on the commonly used PC has reached the order of GHz. Similar to a microcontroller, a PC's RAM and ROM have a capacity that may reach the order of Gbytes as compared to the order of bytes or Kbytes for a microcontroller. Despite having a much slower data processing rate and less memory than a personal computer, a microcontroller nevertheless has the potential to be used in a wide range of applications, especially considering its small size.

2.2. Ultrasonic sensor

A sensor with the ability to transform electrical quantities into sound and physical or acoustic qualities into electrical quantities is known as an ultrasonic sensor. Reflected sound waves serve as the foundation for how this sensor operates. This ultrasonic sensor may be used to determine whether an object is there or how far away it is by using the sound wave's reflection off of a certain field. It is possible to determine and estimate the object's distance using a certain frequency of reflection. Because this sensor employs ultrasonic waves or ultrasonic sound as feedback, it is known as an ultrasonic sensor.

Ultrasonic waves are sound waves with a frequency of 20,000 Hz, which is quite high. Certain ultrasonic noises are audible to certain animals, including dogs, cats, bats, and dolphins, but they are inaudible to the human ear. It is possible for ultrasonic sound to travel through solids, liquids, and gases. On the surface of a solid, ultrasonic sound reflects with a reflectivity that is virtually identical to that of ultrasonic sound on the surface of a liquid. Therefore, in this investigation, the height of the water below the water's surface will be measured using ultrasonic sensors. However, materials like textiles and foams are easily permeable to ultrasonic sound waves, which leads to less than optimal measurement results.

The temperature of the surrounding area must also be considered when using this sensor to determine the depth of the water. Even a little temperature variation may result in inaccurate measurements since the speed of soundwaves is not constant.

2.3. LCD (liquid crystal display)
The LCD (Liquid Crystal Display) has the ability to display numbers, characters, and symbols more clearly. Low current consumption is a benefit of LCD panels. The dot matrix LCD (Liquid Crystal Display) is an LCD module utilized in this study to display the values obtained from sensing the water level. The character viewer (LCD) part of the dot matrix M1632 LCD (Liquid Cristal Show) module is used to display characters. This LCD also has an integrated microprocessor in the form of a module, which is located at the LCD's back. This microcontroller controls communication between the LCD and the microcontroller used with the LCD module within the LCD as well as the display on the LCD screen. The LCD M1632 is an LCD module with a 2x16 display layer, or 2 rows × 16 columns.

2.4. Air temperature sensor (DHT11)
The measurement instrument used for this study must carefully take input ambient temperature into consideration because temperature depends on location. In this investigation, the temperature was measured via a DHT11 sensor. This DHT11 sensor comprises two sensors: a temperature sensor and a humidity sensor, both of which produce digital data as their output. The information from this sensor's output will be utilized as the microcontroller's input value. The temperature value will then be shown on the LCD layer using this output after further processing. Temperature and humidity may both be measured simultaneously by a sensor called the Sensos DHT11. This DHT11 sensor offers a very high level of stability and a calibration feature that is quite precise. A thermistor of the NTC (Negative Temperature Coefficient) type is included in this sensor and will be used to monitor temperature. The DHT11 also features an 8-bit microprocessor that processes the two sensors and a resistive type humidity sensor. The outcomes will be transmitted by this microcontroller in a single-wire bi-directional fashion to the output pin. A calibration function with a respectable degree of accuracy is present on each DHT11 sensor. The inbuilt sensor will detect the signal while the calibration coefficient is being put into the OTP program memory.

2.5. Power supply
An electrical device known as a power supply serves the purpose of supplying voltage and electric current to other components that need those two things in order to operate. Basically, a power supply needs an external power source, which will be transformed into the precise power source required by different electronic devices. In this investigation, a DC power supply was employed to provide the microcontroller unit with the necessary 5 volts of power. This power supply unit's ability to produce at least 1 amp for the current rating is adequate for the measuring instrument to function correctly.

3. Methods and materials
An experimental investigation has been conducted into the accuracy of digital instrument design for detecting water level and water temperature in irrigation channels. The creation of the digital water level measurement design will be tested against manual measurement to determine the percentage difference. This study used V-notch discharge measurement for the discharge measurement (figure 1). Figure 2 depicts the manual water level measurement. Figure 3 shows the manual method for visually measuring the water level. technology for measuring digital water levels.

Figure 1. V-notch discharge measurement.

Figure 2. Water level measurement.

Figure 3. Manual water level measurement.

Figure 4. Digital water level measurement.

3.1. Measurement device block diagram

This diagram shows how input data from sensors is obtained, processed by the microcontroller, and measured by using a straightforward equation. After completing the equation's calculation, the microcontroller unit will display the solution on an LCD screen.

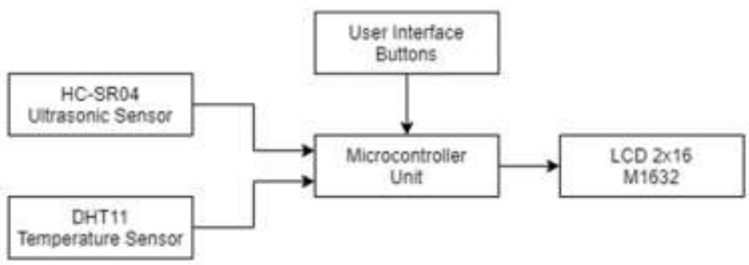

Figure 5. Measurement device block diagram.

$$d = \frac{t * 0.348}{2} \quad (1)$$

The HC-SR04 sensor measures the ultrasonic soundwave duration in microseconds and measures depth (d) in centimeters. Since an ultrasonic sound wave travels back and forth, the equation (1) must be divided by two to accurately represent depth. Please take note that the speed of a soundwave at ambient temperature is 348.369 m/s, hence this equation only applies at that temperature. The d=(t*0.0348)/2 temperature sensing unit is very important for this obvious reason, because the constant value stated in this equation is approximately 0.0348 and must be accounted for temperature variations.

3.2. Rating curve measurement

A rating curve in an irrigation system is a graph showing discharge in relation to stage at a specific point on the irrigation system, often at gauging stations where the discharge is determined using a flow measurement across the irrigation channel. Several discharge measurements are taken over a variety of irrigation channel stages or water levels. The rating curve is a crucial tool in irrigation channels because a good stage-discharge relationship at the gauging station is crucial to the accuracy of discharge data values. In this study, the accuracy of the digital measuring device for water level and water temperature in the irrigation channel was evaluated using the percentage difference. If the calculated discharge is greater than the given discharge, reduce the gate opening, otherwise increase it, and repeat the process until the difference between the calculated and the given discharge is small [5]. Based on that method as well, the results can be seen on table 1, table 2, table 3 and table 4.

Table 1. The percentage difference for Q50%.

Experiment	%Difference
1	0.1
2	0.1
3	0.1
4	0.2
5	0.2

Table 2. Percentage difference for Q10%.

Experiment	%Difference
1	0.3
2	0.3
3	0.2
4	0.3
5	0.3

Table 3. Percentage difference for Q10%.

Experiment	%Difference
1	0.3
2	0.3
3	0.2
4	0.3
5	0.3

Table 4. Percentage difference for temperature.

Experiment	%Difference
1	0
2	0.01
3	0
4	0
5	0.01

4. Result and discussion

The significant development offers utility decision makers concrete learning to speed their adoption of digital solutions and address pressing water concerns by examining how digitalization is affecting the water industry, particularly in irrigation projects. The result displays the percentage difference between analog and digital methods for measuring water levels. It is possible to infer that it is crucial to use digital tools, especially when determining the water level in irrigation channels. Figure 6 shows a rating curve.

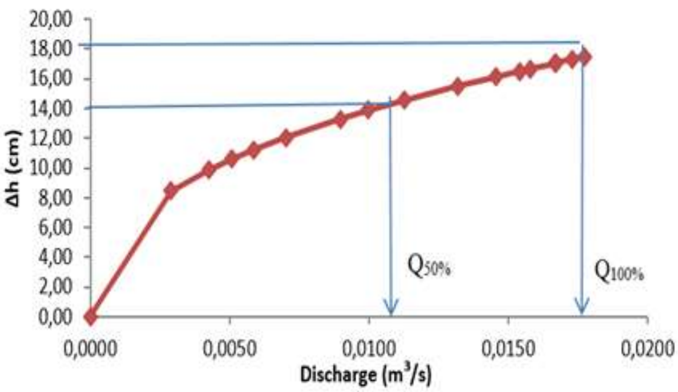

Figure 6. Rating curve.

Depending on the size and form of the stream, discharge rating curves can be simple or complicated. Stage and discharge are frequently related through empirical research using repeated observations. To establish the rating curve for a certain stream, these data are plotted against the contemporaneous stage. Furthermore, to construct the stage discharge connection throughout the complete range of stream flow data, several discharge measurements are required.

5. Conclusions

In the decision-making process, the sensitivity analysis was the final stage where the input data were slightly modified in order to observe the impact on the results [6]. If the ranking did not change, the results were said to be robust. In short, we needed to see whether the small variations in the weights would change the decision. If not, we would be reassured that our choice was reasonable. Precision and performance are the primary operating criteria for irrigation gates and other metrics. Due to the continuously changing water level as well as outside disturbances, the water level data monitoring based on a typical measurement frequently produces incorrect findings. Additionally, in some circumstances, it's necessary to measure the discharge flow in addition to the water level in order to manage water excess or shortage. This work suggests a precise non-contact water measuring system based on a microcontroller, an ultrasonic sensor (HC-SR04), and an air temperature sensor (DHT11) to detect the water level in a channel without any touch in order to address these problems. The speed of ultrasonic emission while measuring distance is impacted by the variation in air temperature. At a gauging station, the channel conditions downstream from the gauge determine the stage-discharge relation for open-channel flow. Therefore, a fundamental understanding of the channel characteristics that govern the stage discharge relation is essential for creating rating curves.

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