PEAT

Dam Gate Automation Control System by Using Arduino

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Abstract: Every aspect of our lives is connected with the control systems in some way. Control systems are the result of collaboration between hardware and software designers. Even in this day and age of advanced technology, some dams still perform dam gate control procedures manually. There will be human faults and weaknesses if it is done manually. This project describes the creation of a control system for "Dam Gate Automation Control System Based on Arduino". The objectives are to propose a control system for gate opening based on water level, design a control system of dam gate that can work fully automated by using Arduino and fabricate a prototype of the dam gate control system. With implementation of water level sensor, the opening and closing of the dam gate can be controlled by sending signal to servo motor to control the dam gate's movement. At various levels, the water level is monitored, and the gate is controlled to close or open.

Keywords: Control System, Arduino, Servo Motor

1. Introduction

A dam is a barrier to water or underwater streams that stop or restrict their flow. A dam can also be used to gather water or to store water that may be spread evenly over multiple places. The dams have enormous economic boost and growth potential. They can aid in the control of floods and famines, generate electricity, decrease water and power shortages, give agricultural water to low-lying areas, and offer drinking water in isolated locations. Dams are often built with a drain or similar system to control water levels in an impoundment for routine maintenance or emergencies [1].

This dam gate control system based on Arduino Uno can overcome those conditions and automatically manage the reservoir water level. Water is sensed at two levels to close or to open the gate at two levels. This is when the water level is above the point level of the threshold, the gate opens and the door shuts automatically when the water level goes down. Therefore, control system of dam is very crucial in maintaining the eco-structure and to maximize the function of the dam. If properly

programmed, the process's efficient operation and safety considerations will achieve the desired results [2].

Unfettered water flow from a reservoir is essentially a dam failure due to structural dam faults. However, dam failures can vary from small to disastrous and may put people's lives and property downstream in jeopardy [3]. Water shortages in Malaysia have become a severe concern, and several causes are at fault, including insufficient water supplies and inefficient water-saving practices. But the wrong opening and closing of the dam gate based on the water level in the dam is a crucial cause.

Even in this age of sophisticated technology, there are still dams that carry out dam gate control operations manually [4]. The problem with this manual operation is, it is controlled by human manpower. When it is done manually by human, there will be human errors and flaws. When the unexpected happens like it rains very heavily, the dam can be filled up in short period of time and it will cause the dam to handle too much of water pressure which can cause it to burst. If the manpower who responsible to monitor the dam situation get asleep or inattentive, it will lead to failure of dam and high probability of disastrous flash flood to occur. The control system was created with the intention of addressing these flaws [5].

Every Arduino was programmed differently according to the needs and goals. In order to successfully programmed the Arduino, research and study must be made to achieve the correct way to do it. The Arduino will control the opening and closing of the dam gate based on the signal input from the sensor.

The paper aims to propose a control system for gate opening based on water level. The main purpose is also to design a control system of dam gate that can work fully automated by using Arduino. The goal of this project is to fabricate a prototype of the dam gate control system.

2. Methodology

A block diagram is a system diagram in which the main pieces or functions are represented by blocks connected by lines that show the blocks' relationships. Figure 1 shows the block diagram of the dam gate automation system.
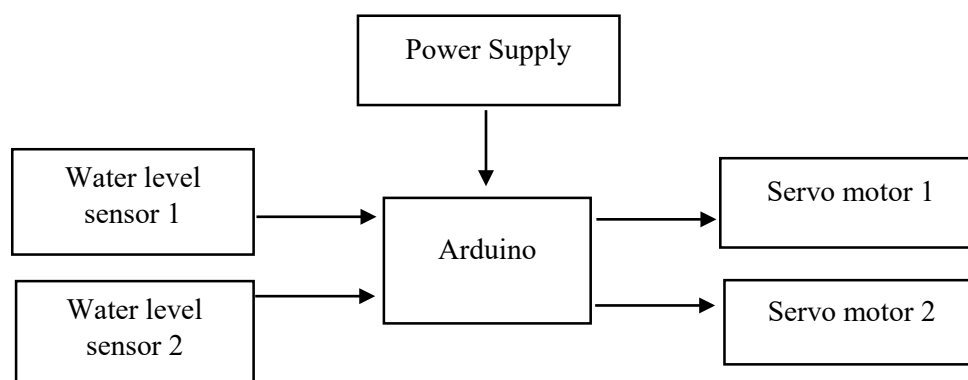

Figure 1: Dam Gate Automation System Block Diagram

Based on Figure 1, there are 2 inputs and 2 outputs. The inputs are two water lever sensors, use to indicate two different water level and the outputs are two servo motors which control the movement of the dam gate.

2.1 Circuit Diagram

A circuit diagram, as opposed to a block diagram or a layout diagram, depicts the actual electrical connections. The term artwork or layout, physical design, or wiring diagram refers to a drawing that

depicts the physical arrangement of cables and the components they connect. Figure 2 shows the circuit diagram of Arduino.
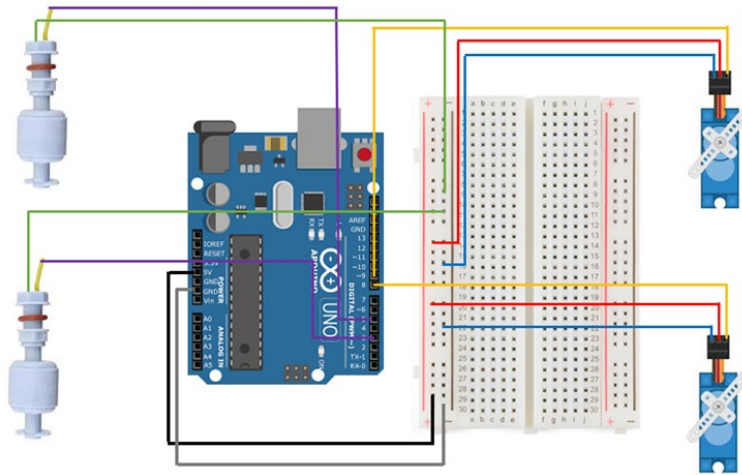

Figure 2: Circuit Diagram of Arduino

2.2 Software Development

Software development is required as part of the data and information collection for this project. The Arduino software (IDE) is utilized in this project. The Arduino IDE is used to develop and design the programming code.

This project's programming code was created using this software for Arduino Uno controller. The programmer may simulate the coding before uploading it to the Arduino controller board. This program's operating platforms are Windows, macOS, and Linux. Because this software is open-source, it is simple to develop code and upload it to Arduino-compatible devices. Figure 6 depicts the Arduino IDE software's version and developer.

Figure 3: Arduino version and developer

Based on Figure 3, Arduino IDE version 1.8.16 was used as the programming software to program the Arduino. The Arduino code is written in C++ and includes specific methods and functions.

2.3 Hardware Development

Table 1 shows the list of the components for dam gate automation control system by using Arduino.

Table 1: List of Components

Component	Description	Operating supply
Arduino Uno R3	Microcontroller	Input voltage: 7V – 12V
SN-WATER-FLOAT	Level Sensor	Max switching current: 1.0A
Servo motor SG90-180deg	Actuator	Operating voltage: 4.8V - 6V

In order to test the prototype performance, a proper preparation has to be made. Figure 4 shows the preparation for the testing to ensure the result obtained can be analyze correctly.
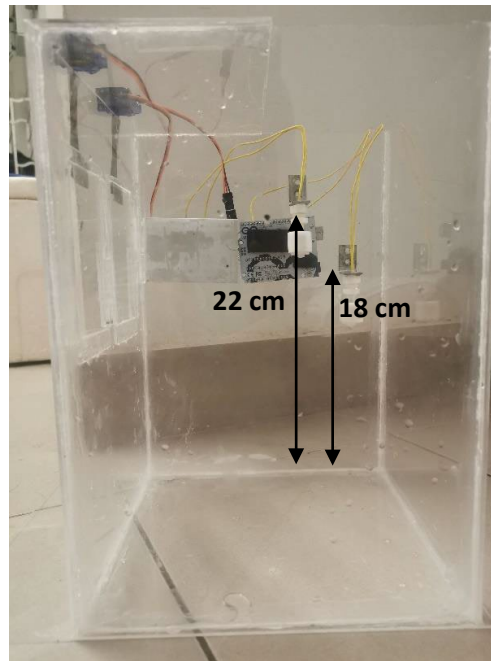
Figure 4: Preparation for Prototype Testing

Based on Figure 4, two water level sensors were placed at two different level, 18 cm and 22 cm respectively. The prototype will be filled with water. Test was conducted on the prototype to identify the response of the sensor to the movement of the dam gate.

3. Results and Discussions

This topic provides the findings and results obtained from the project study of dam gate control system based on Arduino.

3.1 Actual Project Circuit

The circuit have been completely connected accordingly to the circuit diagram shown in Figure 2. Based on Figure 5, the project circuit consists of 1 Arduino Uno board, 1 breadboard, 2 water level sensors and 2 servo motors. The components are connected using male-to-male jumper wire. From Figure 5, we are able to determine the flow of the project circuit
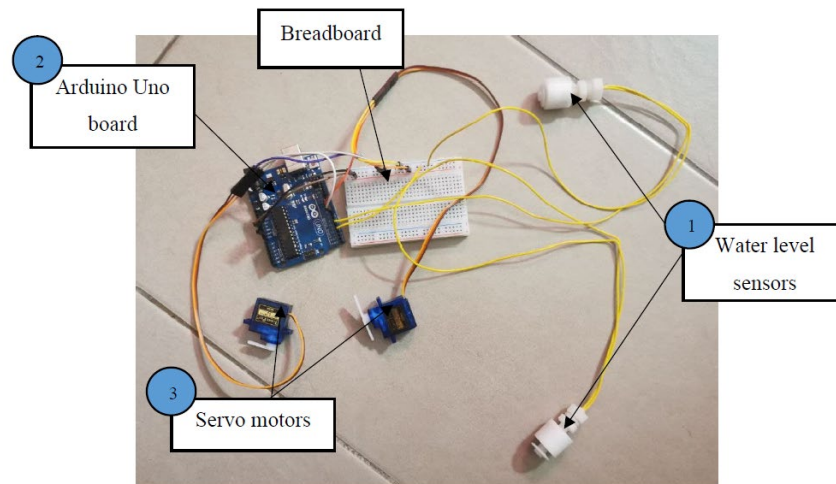
Figure 5: Actual Project Circuit

Firstly, when the water level reached the level of 18 cm or 22 cm, the water level sensor will be triggered. Then, the water level sensor will send a signal to the Arduino, where the input from the sensor was processed and then send signal to the servo motor to move the dam gate. Figure 6 represents the flow of the project circuit.
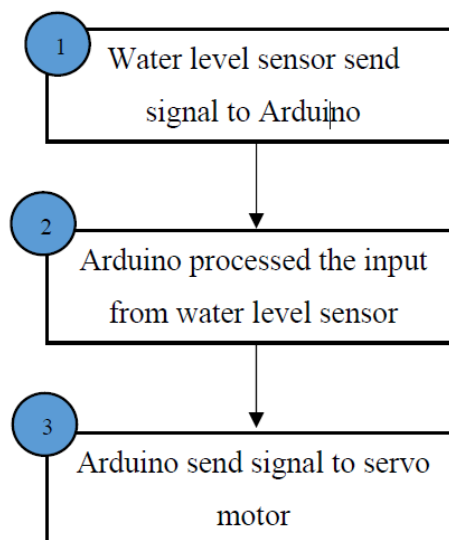

Figure 6: Flow of the Project Circuit

3.2 Prototype Performance

Test was conducted on the prototype to identify the response of the sensor to the movement of the dam gate. The water level is monitored at various levels, and the gate is regulated to close or open. The water level sensor monitors the amount of water in a container. It may then send that data to other devices, which control what happens to the water after that. When the water level sensor was triggered, it will send signal to the servo motor which control the opening and closing of dam gate based on the Arduino coding programmed earlier. Figure 7 illustrates the movement of dam gates at water level of 18 cm and 22 cm.
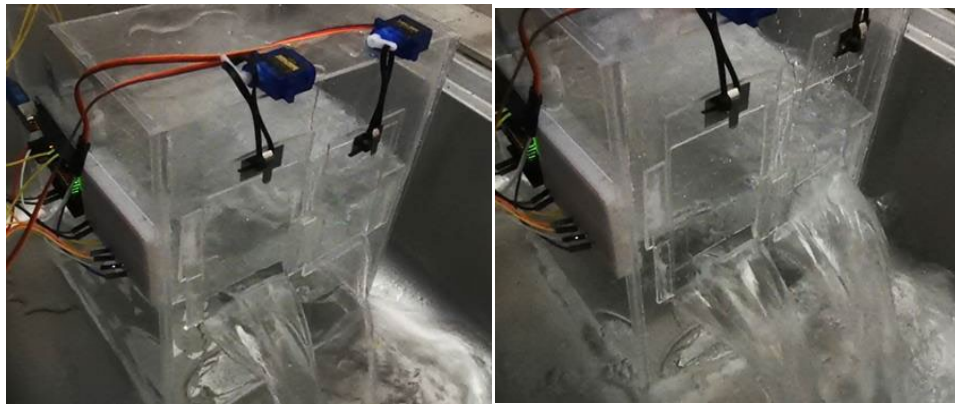
Figure 7: Movement of Dam Gate at Water Level of 18 cm and 22 cm; (a) a) At water level of 18 cm; (b) At water level of 22 cm

Based on Figure 7(a), when the water level reached 18 cm, Water Level Sensor 1 was triggered and it will send a signal to servo motor which control Dam Gate 1 to pull the dam gate up. When the water level decreased and not triggered Water Level Sensor 1, the servo motor will move the dam gate down.

Based on Figure 7(b), when the water level reached 22 cm, Water Level Sensor 2 was triggered and it will send a signal to servo motor which control Dam Gate 2 to pull the dam gate up, while Dam Gate 1 remains open. When the water level decreased and not triggered Water Level Sensor 2, the servo motor will move the dam gate down. Figure 8 represents the flow of the prototype output.
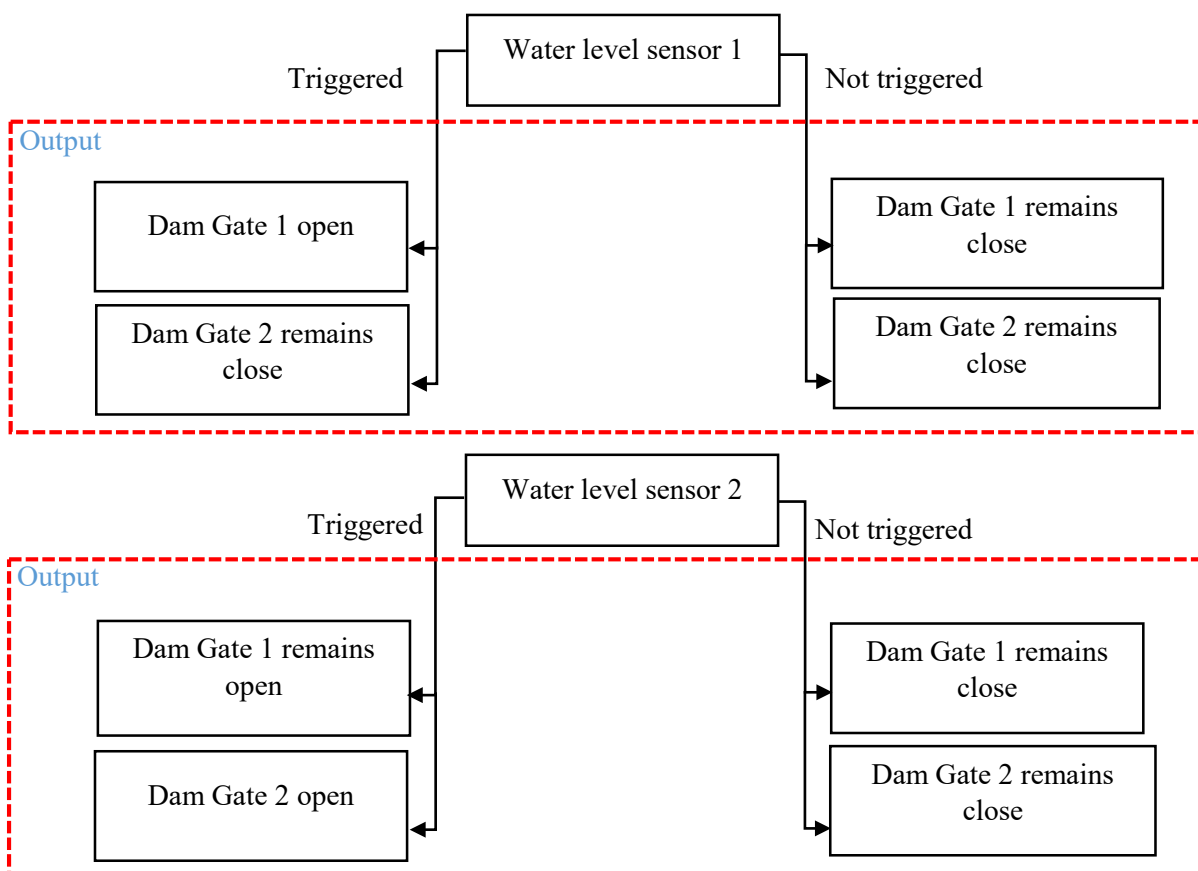

Figure 8: Flow of the Prototype Output

From previous research, Programmable Logic Controller (PLC) was used as the microcontroller, which manages the entire system's functionality [6]. In this project, Arduino was chosen as the

microcontroller because the Arduino platform was intended to provide a low-cost and straightforward way for amateurs, students, and experts to build devices that interact with their environment using sensors and actuators [7].

Next, the selection of servo motor SG90 is important due to its characteristic which the angle of rotation can be easy calibrated by using Arduino IDE [8]. Other than that, servo motors can work at a broad range of speeds, both high and low, without overheating, and they can retain enough torque at zero speed to keep a load in place. Compare to previous research, DC Motor in Arduino-based systems can only be calibrated in terms of speed and direction of rotation, but not the angle of rotation [9].

Other than that, the selection of water level sensor's height was to indicate the capacity of water inside the dam. Water Level Sensor 1 was placed at 18 cm to indicate the capacity of 65.00 %, while Water Level Sensor 2 was placed at 22 cm to indicate the capacity of 80.00 %. The percentage rate indicates the total capacity that needs to be filled with water to trigger the water level sensor, where 65.00 % indicated dam was at alert level and 80.00 % indicated dam is at dangerous level. The placement of water level sensor at different level will affect the movement of the dam gate.

Lastly, to trigger Water Level Sensor 2, the increase in water level should be done at a faster rate to simulate the heavy rain. This is because when Water Level Sensor 1 has been triggered, Dam Gate 1 was in open state and caused water to flowed out through Dam Gate 1. When water was released out through both of the gates, the water level of the dam will decrease faster. As a result, the water pressure in the dam will be reduced and can prevent damage to the dam.

4. Conclusion

Dam Gate Automation Control System by Using Arduino main objectives had successfully accomplished. The project scope also achieves the target while many problems come and solved. In order to complete the prototype, there are 3 main components used, which is Arduino Uno, water level sensor and servo motor. Also, the performances and the effectiveness are approved during testing stage by choosing Arduino Uno R3 which is sufficient to program the dam automation system prototype. The results show that the dam gate movement can be controlled based on the water level, depending on what height the water level sensors were placed.

Although it is just a prototype, but it serves the purpose which is to release water from the dam when it reaches certain level. By doing this project, it can bring a new concept of automation system, not only for small industries but it can be applied to mega industries.

4.1 Future Improvement

After completing this project, there are few recommendations that can be made to improve the efficiency of the project. Firstly, the Arduino Uno board and breadboard can be covered with waterproof case to prevent the occurrence of any short circuit. When the water was filled into the dam, there is a probability of water splashes, which will cause failure for the Arduino to function.

Next, alarm system can be added to give warning to nearby residents before the water is released from the dam. This can be crucial to avoid any injuries to people or their belongings, because the likelihood of flooding is high when large amounts of water are released from the dam. Last but not least, the addition of dam gate(s) can help the outflow of more water to help the dam to better withstand high water pressure.

Acknowledgement

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