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AUTOMATIC MULTIPLE USER ABLUTION SYSTEM

Audu, Abdulkadir. Iyyaka[1*] and Gulani, Mu'awiya. Dauda[2]

[1,2]Department of Computer Engineering, University of Maiduguri, P.M.B 1069, Maiduguri, Nigeria

- Corresponding Author: lm324fairchild@yahoo.com

ABSTRACT

Muslims are obliged to perform ablution (Wudhu)before prayer or other deeds. The ablution stations usually employ the use of manually operated water taps, which are not capable of controlling the water flow and leads to too much of water wastage in the process. This research developed a system called Automatic Multiple Users' Ablution System to tackle the problem through automating the process. The system uses ultrasonic sensors to detect human presence and an Arduino mega-2560 microcontroller as the CPU. It sends the "on" and "off" instructions to the relay to activate the DC mini pump to allow water flow. This allows the system to work only when needed and users are not required to touch the valve in order to activate the water flow. The system is capable of detecting the presence of human in the range of 6cm maximum below the tap. The use of an automatic ablution system will significantly reduce unnecessary wastage of good water compared to manual tap, due to the fact about 2400 cm^3 of good water can be saved by each tap (i.e. 11.76% of the water wasted using the manual tap), which can be generalized to all the eight taps, that is approximately 19200 cm^3 amount of water is saved using the automatic ablution system compared to the manually operated tap.

Keywords: Ablution; Prayer; Control water usage; Multiple user; Automatic taps; Manually operation; Arduino mega-2560 Microcontroller; Ultrasonic sensor; DC mini pump.

1. INTRODUCTION

Ablution is a mandatory religious routine for Muslims that is repeated several times daily for prayers and other deeds. The Ablution action typically includes washing of hands, mouth, nose, face, arms, swabbing on head, ears and feet (Zaied, R. A. 2017). It can take 1 or 2 minutes depending on how fast one is. Muslims do perform this act at a designated place called the Ablution system or station.

The ablution systems or stations are usually found in mosques, which consists simply of rows of mostly manually operated water taps with a drainage trough to carry greywater to main drains. The manually operated water taps are not capable of controlling the flow of water during the ablution process which leads to the problem of portable water wastage, this is becoming so alarming, because a Muslim will use six to nine liters of water during ablution, adding that only two liters of water was used for the whole ritual (Besari, A. R. A. *et al.* 2009). The ablution ritual consumes large amount of water, as the taps are usually left running during ablution, much good water is wasted in the process. It can be said that about half of the tap water flows directly to the drain without any contamination (Al Mamun et. Al., 2014).

The conservation of water is a very important aspect religion and a national obligation especially with lack of water resources in many places. Therefore, it is necessary to exercise some level control on the process to tackle the issue of water wastage and maintain hygienic environment for ablution. Hence, there is an extreme need for automating the process in order to reduce the wastage of good water. Figure 1 shows a picture of an existing ablution station Central Mosque, Damaturu, Nigeria.

Figure 1. Ablution Station of Central Mosque Damaturu.

This research develops an automatic multiple user ablution system in order to prevent the taps from being opened needlessly during ablution. The system reduces fresh water wastage in the process of ablution.The design ensures the reliability of the taps in terms of availability of ablution water and to also help in maintaining cleaner and hygienic environment. The implemented work prevents the drainage system from unnecessary spillage due to too much of water that flows directly into it or blockage due to deposing of used sachets (for sachet water). The quality of the ablution system is maintained easily, as people performing ablution need not to directly touch the taps in order to dispense water.

The automation of the ablution station requires two main aspects of design which are the hardware and software aspects. The hardware aspect consists of the components and interconnections that allows the system to operate according to the instructions prescribed by the software program. The software aspect is the step-by-step detailed instructions that is loaded on the microcontroller, which allows the system to work without the intervention of man.

This paper is organized as follows. A review of related is given in section 2. Section 3 gives a brief mention of electronic and electrical components. The method used in this work is discussed in Section 4. Discussion about the results and outcome of this work is presented in Section 5. Finally, in Section 5, conclusion about this work is drawn.

2. LITERATURE REVIEW

Automation has become a very important tool for delivering service with minimal intervention of humans and a way to make our work easier. With the increase in technology, some of our religious activities too can be automated without resulting in any innovations (Bid'a) that are not allowed in Islam. This brings about the design of an automatic ablution system for multiple users, the system that have the ability to dispense water automatically and save much water when Muslims wants to do pre-prayer cleansing called wudhu ablution.

(Hulukati et al., 2019) in their research titled:"A Prototype of Solar-Powered Automatic Ablution Tap", the system was developed to reduce water wastage during ablution exercise. Thesystem uses an ultrasonic sensor to detect human presence and employs an "Arduino" microcontroller. It sends the "on" and "off" instructions to the relay to activate the solenoid valve to allow water flow. So, the user does not need to touch the valve to activate water flow. This designed automatic control system was aimed at reducing the excessive water consumption when performing ablution.However, the system was designed to be used by a single user at a time, whereas at the ablution station many people are expected to use the system at the same time. Hence the need for an automatic multiple users tap system.

The work of (Suratkon et al., 2014)is published by the Canadian Center of Science and Education. It istitled"Smart WUDHU: Recycling Ablution Water for Sustainable Living in Malaysia" the research is aimed at reducing the large amount of water consume during ablution exercise. A simple recycling system capable of collecting, treating and reuse of the greywater generated during ablution ritual for non-potable water applications, such as toilet flushing, general washing, plants watering and flowerbed cultivation was developed. Hence, the system can capture and channel the greywater through its basic treatment, to be recycled and reused for non-portable applications. However, the system is not capable of reducing the amount of good and portable water wasted during the ablution exercise, since the recycled water can only be used in non-portable applications. This brings the need for system that can reduce the amount of portable water wastage before contamination.

The research conducted by (Widyaningrum 2020) aimed at tackling water wastage during ablution or hand washing and also in determining the most suitable sensor for the design of automatic faucet system between ultrasonic sensor and PIR sensor is an automatic faucet. The system uses an Arduino mega2560 microcontroller as processor and uses ultrasonic sensor and Passive Infrared Receiver (PIR) sensor interchangeably to detect the presence of objects. The difference in the response time of the two sensors were obtained at different time interval and the results were compared. Based on the research result, it was revealed that the ultrasonic sensor is faster than the PIR sensor.However, the system is design for single user only while the ablution station is expected to used be used by many people at the same time.

(Besari, A. R. A. et al. 2009) designed an "Automatic Ablution Machine using Vision Sensor". This machine allows a Muslim to perform the cleansing ritual without water spillage and is environment-friendly as it encouraged water conservation. The machine uses camera as sensor and servo-motor as an actuator that is embedded on crane to turn and open it based on and object under the crane. It means that if there is an object under the crane, it will be opened, and when there is no object under the crane, it will be closed. The system also uses an adaptive method to detect how much water that Muslim need in ablution. Experiment results shows that the system is capable of significantly conserving water during ablution. However, the use of camera as a sensor has its own drawback as it will consume high power and the servo-motor can be replaced by solenoid for more accuracy in the discharge of the water.

(Zaied, R. A. 2017) Conducted a research on the "Water use and time analysis in ablution from taps" to the issue of lack of water resources and an extreme use of potable water in our Arab region. Five different tap types were investigated for water consumption fashions including traditional mixing tap and automatic tap. This research revealed that 22.7-28.8 % of ablution water is used for washing of feet and the largest water waste occurs during washing of face portions, where 30–47 % amount of the water consumed in ablution from taps is wasted which can be saved if tap releases water only at moments of need. The system uses a push-type tap for use in ablution facilities, and incorporated with batch duration and volume such that when performing ablution, the batch duration and volume must be tuned. Therefore, since each batch of 0.25 L of water lasts for 3 s, 3 L in average is sufficient for one complete ablution which means considerable saving compared to the 6–9 L of water normally required. However, the system may be damage as the push-button requires on to have a physical contact with machine. Automated system is more desirable in this case.

3. MATERIALS AND METHOD

3.1. Materials

The research developed a prototype of an automatic multiple users' ablution, consisting of array of eight different taps that are independently controlled by the same microcontroller. The system design consists of the following components:

1. Arduino mega microcontroller
2. Ultrasonic sensor
3. 5V DC mini pump
4. 12V charger
5. 5V relay
6. Transistor
7. Diodes
8. Vero board
9. Jumper wire
10. Water tank

3.1.1 Ultrasonic sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into electric signal.

The program loaded on the microcontroller controls ultrasonic sensor. This is done by supplying a 10μS pulse to the trigger input to start the ranging, for the module to send out a cycle burst of ultrasonic sound at 40kHz and raise its echo.The basic principle of work is as follow

- Using IO trigger for at least 10us high level signal,
- The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
- IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2

Sound travels at approximately 340 meters per second. This corresponds to about 29.1μs (microseconds) per centimeter.

The "2" in the formula is because the sound has travel back and forth. First the sound travels away from the sensor, and then it bounces off of a surface and returns back. The output of the ultrasonic sensor is a high pulse.

3.1.2 DC mini pump

The DC submersible mini water pump is used in this design to pump water to the taps. It is capable of pumping up to 120 liters per hour. This small size submersible pump motor can be operated from a 2.5 - 6V power supply and with very low current consumption of 220Ma. However, the output current of the Arduino mega-2560 microcontroller 40mA which is 5.5 times less than that of the DC mini pump input current and not capable of driving the motor. Therefore, a 5V relay module was incorporated in the design to switch "ON" and "OFF" the DC pump as instructed by the microcontroller.

3.1.3 Arduino mega-2560

The microcontroller is a small and self-contained computer on-chip that can be used to control peripheral devices, which functions as the main CPU. The ATmega2560 is the microcontroller selected for this project due to the number of digital pins required to implement the project design.

The Arduino Mega 2560 is an 8-bit microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

3.2. Method

These materials were put together as depicted by the block diagram in Figure 2 below.

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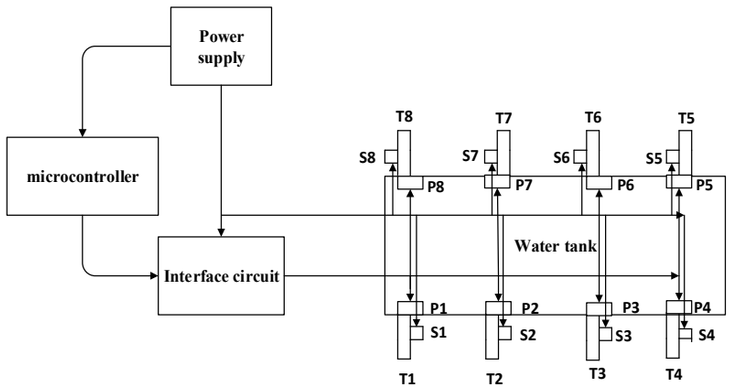

Figure 2. System block diagram.

The system consists of eight DC pumps, eight ultrasonic sensors and eight tap outlets as shown in the block diagram above (denoted by P1-P8, S1-S8, and T1-T8 respectively). These DC mini pumps are submerged into the water tank and each of the pumps is connected to a tap outlet independently. An ultrasonic sensor designated to transmit obstacle within a maximum range of 6cm is positioned appropriately below each of the eight taps (i.e. for each DC pump there exist an associated ultrasonic sensor to send a signal and a tap to dispense water).

The interface circuit consists of eight relay modules that acts as switch for controlling the opening and closure of the taps independently, since the output digital signal from the microcontroller cannot run the DC pump directly.

The system is powered by a 12V DC charger that is energize by the mains electricity supply and uses the eight different ultrasonic sensors that are positioned appropriately below each tap outlet to detect presence ofhuman at the length between 2-6cm and sends the digital signal (either “High” or “Low”) directly to the microcontroller through its input pins. It employs the use of an Arduino mega 2560 microcontroller which functions as the main central processing unit.The flowchart describing the system’s operation is shown in Figure 3 below.

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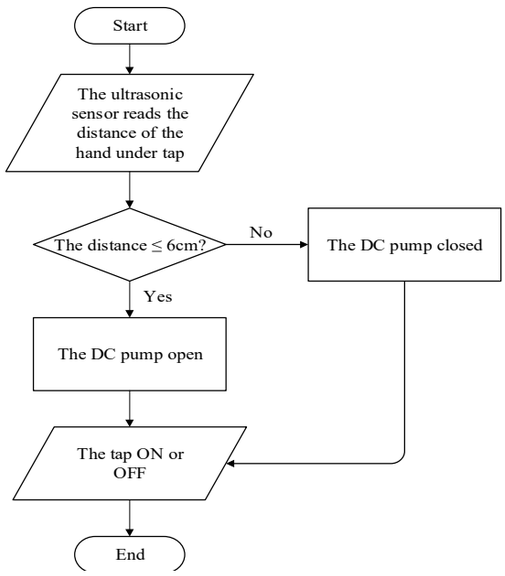

Figure 3 System circuit diagram.

The Arduino mega-2560 microcontroller will process all the digital signals received through the digital input pins connected to the ultrasonic sensors and route the digital information (either "ON" or "OFF") to the output pins which are connected to relays, and controls the opening and closure of the relay module.
The relay serves the switch that turns "ON" or "OFF" the taps according to the instruction received from the microcontroller.

4. RESULT AND DISCUSSION

The prototype was tested to measure the time need by the ultrasonic sensor to open the water tap and the needed to close the water tap. The result given as shown in the Table 1.

Table 1: Flow rate test result

Time (S)	Time Needed by Ultrasonic SensorstoOpen The Water Tap (ms)	Time Needed by Ultrasonic SensorsClose the Water Tap (ms)
2	34	87
3	42	90
4	36	86
5	38	82
6	29	76

The result indicates that the time needed by the system to open the water tap is less than the time needed to close the water tap. The graph is shown in the figure 5.

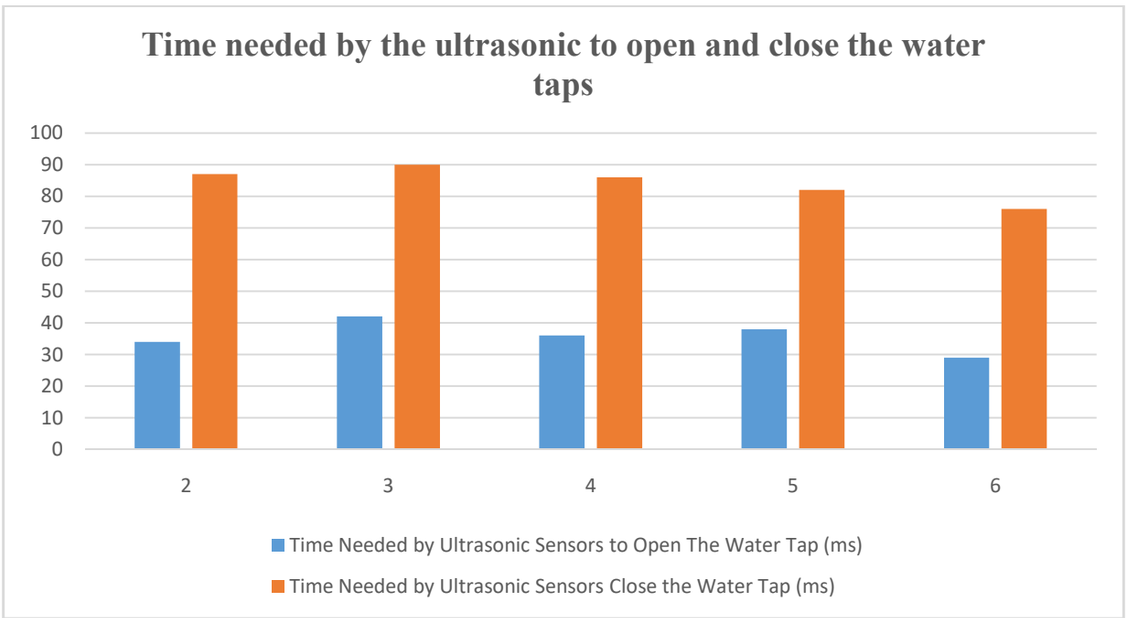

Figure 5:Time needed by ultrasonic sensor to open and close the tap

It can observe from the graph that there is an average of 4ms difference between the opening and the closing
Secondly, a test for the sensitivity of the ultrasonic sensor was carried out for several distances below the taps. This was done to observe the sensitivity of the DC pump to objects below the taps. The result is shown in the Table 2 below.

Table 2: Sensitivity of the DC pump

Distance (cm)	DC pump condition
0	Out of range
1	Out of range
2	Active
3	Active
4	Active
5	Active
6	Active
7	Not active
8	Not active
9	Not active
10	Not active

The test result shows that the prototype is capable of dispense water at a maximum distance of 6cm. when the object is between the range of 2-6cm the system is turn into the "active state" and water flows. However, if the distance of the of object below the taps exceeds the designated maximum distance value (i.e. 6cm), the system will remain in the off state (i.e. "Not active"). Therefore, when there is no object below the taps or object is not within the active range, the taps go off automatically.The 6cm was chosen to avoid unnecessary release of water when an object accidently passes below any of the taps
Lastly, the system was tested to quantify the amount used for ablution and compared with the manually operated tap. The result is given in Table 3 below.

Table 3: The comparison of prototype and manual tap

Time (S)	Volume of ablution water dispense by the automatic system (cm^3)	Volume of water dispense by the manual faucet (cm^3)	Average reduction of water (%)
10	1100	1700	35.29
20	2300	3100	25.81
30	4200	8600	51.16
40	9700	11500	15.65
50	11700	13800	15.22
60	13400	15200	11.84
70	15600	18500	15.68
80	18000	20,400	11.76

It can be observed from the Table 3 above that approximately2400 $cm^3$is saved by using the automatic ablution system (i.e. 11.76% of the water wasted using the manual tap). This was achieved because the system release water only when needed. The result can be generalized for the whole eight taps, since it is design for multiple users. Hence, appreciable amount water can be saved.

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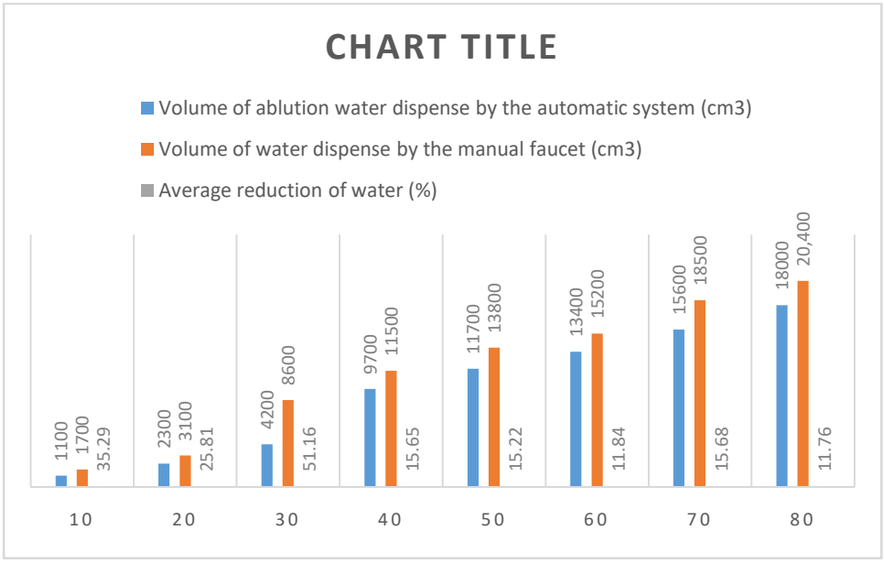

Figure 6: Comparison between the prototype and the manually operated tap

5. CONCLUSION

This research was purposely carried out to automate the ablution workstation in order to significantly reduce the excess amount of good and portable water wasted while using the manually operated water taps. This can be seen in:

- The provision for usage by multiple users
- The maximum distance below the tap is 6 cm to allow the flow of water
- Ability to dispense the water automatically
- Reduce the amount water consume in ablution by 2400 cm^3, which can be generalized to all the eight taps, that is approximately 19200 cm^3 amount of water is saved and
- Prevents the drainage system from unnecessary spillage due to too much of water that flows.

Therefore,the employment of this design in the ablution process will help significantly in reducing the amount of water consumption compared to the ordinary manually operated taps. It will also help in maintaining cleaner and hygienic environment.

Figure 7: Implemented Prototype

The figure 7 above shows the picture of the system prototype. It depicts the real interconnections between the different components that make up the system. It consists of eight taps that well situated evenly on the two sides of the container (i.e. four taps on each side).

6. RECOMMENDATION FOR FUTURE WORK

We do recommend for future enhancement of this technology, the system should include;

- Water level detection circuitry
- A solar power supply for power back up.

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