Comparison of Automatic Water Taps Using Ultrasonic Sensors and PIR Sensors

Vivi Tri Widyaningrum
Faculty of Engineering, University of Trunojoyo Madura, Bangkalan, Indonesia
vivi@trunojoyo.ac.id

Abstract. Water is vital for all living things on the earth, so there must be an effort to save water. One effort to save on water use is by making automatic water taps. Automatic water taps which are meant here are water taps on the sink and also water taps for ablution. The working principle of the two taps is the same, that is, the water tap will open if there is an object (human) detected in front of the water tap. In this automatic faucet system the Arduino Mega 2560 microcontroller is used as data processor obtained from ultrasonic sensors and Passive Infrared Receiver (PIR) sensors. The two sensors are used interchangeably and the results are compared to determine the difference in response time. Based on the tests that have been done, it is found that the time needed for the ultrasonic sensor to open or close the water tap is faster than the PIR sensor. When opening the tap the time needed by the two sensors is almost the same, which is only 4ms difference. Whereas when closing the tap the time needed for the PIR sensor is much longer, which is more than 4s. This is because the process of returning the sensor to return to normal is not detecting the presence of humans or in other words the sensor does not detect infrared rays tend to require a longer time. As for the ultrasonic sensor because what is detected is the distance, so the object moves from the front of the tap then the distance detected will change immediately so that the tap will immediately close again.

1. Introduction
The Earth’s surface is covered 71% of water [1]. Water is vital for all living things on the earth. At 2025 more than half of the world population by some observers are estimated will be facing water-based vulnerability [2]. Then the population of Indonesia by the Central Statistics Agency (BPS) is predicted to increase from 238.5 million in 2010 to 305.6 million in 2035. Though the rate of population growth will greatly affect the increasing need for clean water [3].

One effort to prevent water vulnerability is to save water usage in daily life. At present most taps used in the household are manual taps, for example a water tap on the sink and a water tap for ablution. This of course raises the possibility of negligence in closing the tap after it is finished, so that it will cause waste of water. In addition, when performing ablution, there will also be a waste of water because there will be a gap from one limb to another and at that time the water will continue to flow even though the volume is small. Water saving problems have been developed to avoid water scarcity [4-5].

This study aims to develop automatic water taps in hopes of helping water saving programs. Automatic water taps are made using ultrasonic sensors and PIR sensors. Some studies use ultrasonic sensors [6-7] as well as PIR sensors [8-9], the results show the device can function as desired. The use of ultrasonic sensors in automatic water taps has a disadvantage because ultrasonic sensor detect all
objects including inanimate objects that exist at a certain distance. Therefore in this study try to compare the effectiveness of using ultrasonic sensors and also PIR sensors. In this case the PIR sensor is chosen because this sensor only detects the presence of living things.

2. Method

2.1. System Description

The tool made is an automatic water tap. The tools made are prototypes, as shown in Figure 1. Automatic water taps which are meant here are water taps on the sink and also water taps for ablution. This device does not require the use of a water pump because the water reservoir is positioned higher than the water tap. The principle of working the taps in these two places is the same, that is, the water tap will open if there is an object (human) detected in front of the water tap. In this automatic tap system the arduino mega 2560 microcontroller is used as a processor of data obtained from sensors. Many previous studies related to water have also used the arduino based sensors [10-13]. At this research arduino will be work based on ultrasonic sensor and PIR sensor. Both of these sensors are used not simultaneously, but are used interchangeably with the aim to find out how the difference in speed of response in the process of opening and closing the water tap.

![Figure 1. The results of automatic water tap tools](image)

In Figure 1 you can see the position of the water tap placed in the backyard of the prototype house, with the aim of facilitating the trial process. The test is done by bringing your hands closer to the front of the tap and done with different distances between 1cm to 10cm. Then for each distance recorded how long it takes to open or close the water tap, which is used in this tool solenoid valve.

2.2. Automatic Water Tap Design Using Ultrasonic Sensor

The ultrasonic sensor works based on the emission of ultrasonic waves received by ultrasonic receivers so that the distance of objects (humans) can be interpreted. In this automatic faucet system the ultrasonic sensor serves as a giver of information about the existence of objects (humans) in front of the water tap. If there is an object (human) with a certain distance (the distance is ≤ 10cm) which is in front of the tap, the water tap will open. More clearly, if there are users who want to wash their hands in the sink or users who want ablution, then the hand will block the ultrasonic waves that are emitted so that the ultrasonic sensor can interpret the distance of the hand with the tap. The distance that has been obtained will be used by the microcontroller to determine the opening or closing of the water tap. If the microcontroller determines the object in front of the tap, the hand detected is at a distance of less than equal to 10cm, the microcontroller will give an order to the relay to open the solenoid valve, and vice versa. The working principle in this automatic faucet system with ultrasonic sensors is shown in Figure 2.
2.3. Automatic Water Tap Design Using PIR Sensor

PIR sensor works based on infrared light and is passive because it can only receive infrared radiation. In this automatic faucet system the PIR sensor has the same functions and principles as the ultrasonic sensors discussed in the previous sub-chapter. The PIR sensor also functions as a giver of information about the existence of objects in front of the water tap. If there are users who want to wash their hands in the sink or users who want ablution, then the PIR sensor will detect infrared sources with a certain temperature, which means that a human is detected, so the microcontroller will give a relay command to open the solenoid valve, and vice versa. In this case to reduce the detection area, then the PIR sensor is given a cover around it so that the detection area focuses only towards the front of the tap. The working principle in this automatic faucet system with the PIR sensor is shown in Figure 3.
3. Results and Discussions

The results of automatic water tap testing with ultrasonic sensors and PIR sensors are shown in Table 1. Then the test results are also displayed in graphical form in Figure 4 and Figure 5. Table 1 shows that the time taken by the ultrasonic sensor and the PIR sensor when opening the water tap is faster than when closing the water tap. Then in Table 1 it is also seen that the time difference required by the PIR sensor when opening and closing the water tap is longer than the ultrasonic sensor.

| Hand Distance (cm) | Time Needed by Ultrasonic Sensors (ms) | Time Needed by PIR Sensors (ms) |
|-------------------|---------------------------------------|---------------------------------|
|                   | Open The Water Tap | Close The Water Tap | Open The Water Tap | Close The Water Tap |
| 1                 | 34                     | 82                     | 43                     | 389                  |
| 2                 | 42                     | 91                     | 45                     | 356                  |
| 3                 | 37                     | 88                     | 34                     | 366                  |
| 4                 | 37                     | 91                     | 39                     | 391                  |
| 5                 | 35                     | 86                     | 44                     | 354                  |
| 6                 | 29                     | 82                     | 28                     | 359                  |
| 7                 | 34                     | 82                     | 52                     | 368                  |
| 8                 | 46                     | 97                     | 38                     | 358                  |
| 9                 | 39                     | 90                     | 37                     | 352                  |
| 10                | 31                     | 76                     | 43                     | 356                  |
| Average time (ms) | 36                     | 87                     | 40                     | 365                  |

Figure 4 shows the comparison of the time taken by the ultrasonic sensor and the PIR sensor when opening the water tap. In the graph, it can be seen that the time taken is almost the same, the average difference is only 4ms. Figure 5 shows the comparison of the time taken by the ultrasonic sensor and the PIR sensor when closing the water tap. In the graph it can be seen that there is a considerable amount of time difference, which is the average difference of more than 4s.
4. Conclusion
From the results of tests that have been done, it can be concluded that the time required for the ultrasonic sensor to open or close the water tap is faster than the PIR sensor. When opening the tap the time required by the two sensors is almost the same, which is only 4ms difference. Whereas when closing the tap the time required for the PIR sensor is much longer, which is more than 4s. This is because the process of returning the sensor to return to normal it does not detect the presence of humans or in other words the sensor does not detect infrared rays tend to require a longer time. As for the ultrasonic sensor because what is detected is the distance, so the object moves from the front of the tap then the distance detected will change immediately so that the tap will immediately close again.

References
[1] “CIA - The world factbook". Central Intelligence Agency. Retrieved 2008-12-20
[2] S. N. Kulshreshtha, "A Global Outlook for Water Resources to the Year 2025", Water Resources Management 12 (3):167–184, 1998. doi:10.1023/A:1007957229865
[3] PT Sarana Multi Infrastruktur (Persero), “Sumberdaya Air”, 2017, https://www.ptsmi.co.id/wp-content/uploads/2017/07/SMI_Insight_Q2_2017_IND.pdf
[4] A. Hegde, G. Kiran T. S., Deepti D., T. N. Nagabhushan, S. P. S. Prakash, and A. R. S. Ulle, "Automated Water flow Control System", National Conference on Product Design (NCPD 2016), July 2016.
[5] E. Vinothini, E., and N. Suganya. "Automated Water Distribution and Performance Monitoring System", International Journal of Engineering and Innovative Technology (IJEIT), Vol. 3, Issue 8, February 2014.
[6] T. Wani, M. Raj, T. Raza, and Noble K V, “Design and Development of Automated Faucet Valve Regulating Mechanism”. International Journal of Engineering Sciences & Research Technology (IJESRT), Vol. 3, Issue 8, pp: 795-803, August 2014, ISSN: 2277-9655
[7] H. Y. Jeon, H. Zhu, R. Derksen, E. Ozkan, and C. Krause, “Evaluation of Ultrasonic for Variable-Rate Spray Applications”, Journal of Elsevier, Computers and Electronics in Agriculture, Vol. 75, pp: 213-221, 2011
[8] D. P. Tibe, P. C. Ghodke, I. J. Pawara, A. U. Gupte, and Prof. S. K. Mahindrakar, “Automatic Public Tap Control Using IR Sensor and Water Level Indication Using GSM”, International Journal of Advance Engineering and Research Development (IIAERD), Vol. 3, Issue 5, May 2016, e-ISSN (O): 2348-4470, p-ISSN (P): 2348-6406
[9] R. Vedula, V. K. Bachu, and P. S. P. Reddy, “A Hygienic, Cost Effective, Hand Free & Water Conservative Sensor Faucet”, International Journal of Engineering Inventions (IJEI), Vol. 3, Issue 2, pp: 32-37, September 2013, e-ISSN: 2278-7461, p-ISSN: 2319-6491
[10] E. C. Prima, S. S. Munifah, R. Salam, M. H. Aziz, and A. T. Suryani, “Automatic Water Tank Filling System Controlled using Arduino™ Based Sensor for Home Application”, Proceeding of Elsevier Engineering Physics International Conference, EPIC 2016, Procedia Engineering Vol. 170, pp: 373-377, 2017

[11] B. Mashilkar, P. Kumar, A. Chawathe, V. Dabhade, V. Kamath, and G. Patil, “Automated Bottle Filling System”, International Research Journal of Engineering and Technology (IRJET), Vol. 3, pp: 357-361, 2016

[12] S. Nallani and V. B. Hency, “Low Power Cost Effective Automatic Irrigation System”, Indian Journal of Science and Technology, Vol. 8, Issue 1, 2015

[13] S. V. Devika, S. Khamurudeen, S. Khamurunnisa, J. Thota, and K. Shaik, “Arduino Based Automatic Plant Watering System”, International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, pp: 449-456, 2014

Acknowledgments
The authors would like to acknowledge the research funding support provided by Directorate of Research and Community Service (DP2M) DIKTI, through grant the Beginner Lecturer Research in 2017.