Automatic Infusion Monitoring System Sensor Selection

Using Fuzzy TOPSIS Algorithm

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***Abstract*** *– Infusion system was necessary to support patient in hospital. The problem with infusion system was, it manually monitor by nurse. Few researchers are using low cost sensor and microcontroller to build an automatic monitoring for infusion system. In this paper, we are using fuzzy topsis to propose a simulation to see which sensor are the best for automatic infusion system based on their characteristic and their low price. In this simulation, we are using 3 sensors such as LDR (photo resistor), photo transistor, and photo diode. Using fuzzy topsis methods the photo transistor are emerge as the best sensor with value 1, even though it has the price 6 times higher from LDR sensor and 3 times higher from photo diode.*

***Keywords:*** *Fuzzy topsis, photo resistor, photo diode, photo transistor, infusion system*

**INTRODUCTION**

In this digital age of information everything will be done automatically, and thus less work will be done manually (Spencer, 2018). The automation process was favored better than manual, because it could reduce human error and improve system performance (Haigh & Caringi, 2007). From building car and motor cycle to flying a plane, the automatic process cover broad of fields. Unfortunately, even though automation process was advantageous over manual process, there are jobs that still process manually. Even at emergency systems that involve human life, such as hospital service.

One of medical process that still be done manually, would be infusion process by nurse. Infusion involves the administration of medication through a needle or catheter. It is prescribed for patients whose condition is so severe that they cannot be treated effectively by oral medications (*Medicare and Home Infusion An NHIA White Paper*, 2018). One of the manual infusion process is the nurse need to check infuse level regularly to prevent the infusion liquid from empty (Hamuda, 2019). This manual process infusion check proved to be fatal for patient if the nurse made human error, such as empty infusion lead to death to patient (Krishnananda, Srivastava, N, K, & R, 2014).

To prevent this problem we need the automatic infusion monitoring system. Several researchers propose a simple and cost reduction using general microcontroller and sensor. Wadianto propose Arduino as microcontroller and photo diode as sensor (Wadianto & Fihayah, 2016). Arslan propose to add a wireless communication capabilities using xbee module (Arslan, 2018). Gil and colleagues adding monitor capabilities using PC and android app (Jr, N, & Tanguilig, 2016). Another researcher zhihui adding speed droplet capabilities using motor drive to pull infuse system (Xu, Li, & Xiao, 2013).



Figure 1. Infusion Manual Process

Even though a lot of researcher already made the automatic infusion monitoring system, unfortunately they all focused on the system. Meanwhile there isn’t study about how to select the best sensor for the automatic infusion monitoring system. In this paper we propose the use of fuzzy topsis for selecting the right sensor for automatic infusion monitoring system. The sensor we compare was LDR (photo resistor), photo transistor, and photo diode.

**METHOD**

A fuzzy algorithm was introduce by zadeh at first in 1965 (Bellman & Zadeh, 1970; Zadeh, 1975). He and colleagues invented it to solving real world problem using human logic, which is approximate reasoning from precise and not precise. As the world become more complex and new problem arise, so is the fuzzy. Until now a lot of new fuzzy methods are born to solve real world problem such as monitoring (Riady, Maulana, Suwarno, & Nugroho, 2018), control (Haq, Riyadi, & Sumardi, 2014), supplier selection (Kar, Chatterjee, & Kar, 2014), traffic light (Galang P. N. Hakim, Ahmad Firdausi, Mudrik Alaydrus, 2018), data forecasting (Poulsen, 2009), failure analysis (Supriyadi, Ramayanti, & Afriansyah, 2017), selection admission (Pangaribowo, 2014) and many others.

To solve MCDM (Multiple Criteria Decision Making) problem such as sensor selection for automatic infusion system, we propose the use of fuzzy topsis. Fuzzy topsis was a method to solve MCDM problem using the nearest from the best alternative and hence the farthest from the worst alternative. Therefore the ideal alternative has the best score better from other alternative (Fedrizzi & Molinari, 2013). The fuzzy algorithm was:

**Matrix Decision**

We built the matrix decision using sensor multiple criteria

**Normalize Matrix Decision**

To make sure we can compare for every criteria we need to do normalization. This step was to limit criterion between 0 and to 1 (Wang & Lee, 2009).



(1)

Where i=1,2,….,m and j =1,2,….,n

**Matrix Decision Weight**

The weight of normalize matrix need to be weighted. With this we can emphasis criteria that had a most impact value for user/system. Therefore for weight criteria and their value we are using human decision.

**For Positive Ideal Solution**

The Weight of the normalize matrix decision can be shown as a positive ideal solution as below

  (2)

Where J+ = {j=1,2,….,n│j} criteria that having a positive impact

**For Negative Ideal Solution**

The Weight of the normalize matrix decision can be shown as a negative ideal solution as below



 (3)

Where J- = {j=1,2,….,n│j} criteria that having a negative impact

**Distance for Positive Ideal Solution**

Alternative was the nearest with the best



(4)

Where, i = 1,2,….,m

**Distance for Negative Ideal Solution**

Alternative was the nearest with the best



(5)

Where, i = 1,2,….,m

**Closeness Coefficient**

Using the worst alternative distance and the best alternative distance, closeness coefficient is calculated to shown the best of the alternatives performance as shown below:



 (6)

Where, i = 1,2,….,n

**Simulation**

In this simulation, we are using 3 sensors such as LDR (photo resistor), photo transistor, and photo diode. For sensitivity from 1 to 3 are LDR, Photo Diode, and Photo Transistor (Rammohan & Kumar, 2017). For price of 3 sensors above we see into marketplace in Indonesian sites. Based on sensor characteristic and price we have a decision matrix.

Tabel 1. matrix decision

|  |  |  |
| --- | --- | --- |
| **Sensor** | **Sensitivities** | **Price (idr)** |
| Light Dependent Resistor | 0.26 | 400.00 |
| Photo Diode | 0.22 | 800.00 |
| Photo Transistor | 0.33 | 2500.00 |

Matrix normalization was given at table 2 using equation 1.

Table 2. normalize matrix decision

|  |  |  |
| --- | --- | --- |
| **Sensor** | **Sensitivities** | **Value** |
| Light Dependent Resistor | 0.0006599999 | 0.9999997822 |
| Photo Diode | 0.0002687500 | 0.9999999639 |
| Photo Transistor | 0.0001300000 | 0.9999999916 |

For linguistic weight we are using user experience, therefore the weight value was user decision

Table 3. Weight Linguistic

|  |  |  |
| --- | --- | --- |
| **Item** | **Sensitivities** | **Price** |
| Linguistic Weight | 3 | 1 |

We applied the weight into normalization decision matrix

Table 3. normalize matrix decision weighted

|  |  |  |
| --- | --- | --- |
| **Sensor** | **Sensitivities** | **Value** |
| Light Dependent Resistor | 0.0019799996 | 0.9999997822 |
| Photo Diode | 0.0008062500 | 0.9999999639 |
| Photo Transistor | 0.0003900000 | 0.9999999916 |

Using weighted decision matrix normalization, for positive ideal solution would be

y1+ = Min { 0. 0019799996; 0. 0008062500; 0. 0003900000} = 0.0003900000

y2+ = Max { 0. 9999997822; 0. 9999999639; 0. 9999999916} = 0.0019799996

Therefore for positive ideal solution would be

A+ = {0.0003900000; 0.9999999916}

Using weighted decision matrix normalization, for negative ideal solution would be

y1+ = Max { 0. 0019799996; 0. 0008062500; 0. 0003900000} = 0.0019799996

y2+ = Min { 0. 9999997822; 0. 9999999639; 0. 9999999916} = 0.9999997822

Therefore for negative ideal solution would be

A- = { 0.0019799996; 0.9999997822}

Using equation 4 distances with positive ideal solution become:

Table 4. Distance Alternative from Positive Ideal solution

|  |  |
| --- | --- |
| **Sensor** | **Value** |
| Light Dependent Resistor | 0.0015899996 |
| Photo Diode | 0.0004162500 |
| Photo Transistor | 0.0000000000 |

Using equation 5 distances with negative ideal solution become:

Table 5. Distance Alternative from Negative Ideal solution

|  |  |
| --- | --- |
| **Sensor** | **Value** |
| Light Dependent Resistor | 0.0000000000 |
| Photo Diode | 0.0011737496 |
| Photo Transistor | 0.0015899996 |

Using equation 6 closeness coefficient become:

Table 6. Closeness Coefficient

|  |  |
| --- | --- |
| **Sensor** | **Value** |
| Light Dependent Resistor | 0.0000000000 |
| Photo Diode | 0.7382074948 |
| Photo Transistor | 1.0000000000 |

From the simulation using fuzzy topsis algorithm above, We can get the best sensor for automatic infusion system. on the last equation the Closeness Coefficient table show, the sensor that near value or has value 1 is the best sensor according to the fuzzy topsis algorithm. From table 6 the photo transistor sensors emerge as the best sensor that can be used in automatic infusion monitoring system.

**Conclusion**

In this paper, we are using fuzzy topsis to propose a simulation to see which sensor are the best for infusion system based on their characteristic and price. Using this methods the photo transistor are emerge as the best sensor with value 1, even though it has the price 6 times higher from LDR sensor and 3 times higher from photo diode.

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