Development Analysis of Signal Pedestrian Crossing Capabilities with Arduino Platform

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Abstract---*Growth in population and number of vehicles in big cities results in an increased risk of accidents for road users, especially pedestrians. Based on the Bandung City government report [1], pedestrians are ranked 2nd (two) with the highest risk of death on the highway after 2 (two) motorbike riders, which is 23% of the total number of highway user deaths. The high number of pedestrian deaths is caused by the presence of some motorists who violate vehicle speed limits and ignore pedestrian rights. Technology integration in supporting pedestrian safety, especially when crossing the road is still lacking. Observations in two different places in the center of the city of Bandung, it appears that the new technology is only used to provide a button facility for pedestrians to cross in a very short time scale. The current facility cannot take into account the condition of road waders and vehicle users as well as the weather that occurred at that time. To anticipate the problems, technology integration is more accurate in calculating various conditions around the highway where pedestrians will cross.*

Keywords---*Pedestrian Risk, Technology Innovations.*

I. Introduction

The growth in the number of highway users which is always increasing significantly in big cities is a common thing. Particularly in developing countries, the number of presentations has also increased, due to the desire to have private transportation to become an obsession for the people. Increased growth of road users is not accompanied by growth in the number of roads and the level of awareness in using the road.

Increasing the number of highway users, will result in a higher risk of accidents for road users. This can be seen from the growth of road accident data that continues to increase from year to year [1]. This certainly becomes a matter of great concern for accident victims in particular or the community in general.

The high risk of road user accidents, due to violations of speed limits and neglect of pedestrian rights. Some vehicles that use the highway, do not understand the speed limits for the vehicles they drive. So that accidents that occur due to vehicles that are used outside the control of the driver when something unexpected happens. In addition to motorists, pedestrians are also victims of negligence of motorized motorists who do not pay attention to their rights. Accidents that occur to pedestrians usually arise because of the intersection between vehicles and pedestrians.

Improvements to various road management facilities and systems must always be improved and improved. The application of various technologies that provide a sense of security and comfort for all road users is an interesting thing to research and develop.

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Objectives

The high mortality rate of pedestrians due to accidents on the highway has increased alarming [1]. Besides being caused by negligence from motorists, the high number of pedestrian deaths can be caused by the lack of facilities that can provide a sense of security and comfort for pedestrians by crossing the road. This research will discuss 1) the availability of crossing facilities provided, 2) Conducting analysis for technology integration to add crossing facility features that can increase safety and comfort for pedestrians.

II. Literature Review

Legal

Road facilities are a very important element in transportation activities. The existence of a good road will greatly support the success in the implementation of transportation activities. The success of transportation will greatly help the growth of the people's economy in certain areas. To achieve good management of transportation activities, there are Laws (Laws), Government Regulations, and Ministerial Regulations, Public Works (PU) which are the basis for the provision of these facilities.

Laws of the Republic Indonesia no.38 year 2004 about Road [2]

The government as the holder and operator of the road operator must hold several key principles. As stated in one of the points in article 2, the government as the holder and operator of the road operator must uphold the principle of security and safety for all road users.

One manifestation of carrying out the mandate is to provide various facilities that can be used by all road users. Pedestrians, as one of the most frequent components of road users must also get attention, especially in terms of improving security and safety when using road facilities.

In addition to sidewalk facilities that can be utilized exclusively by pedestrians to be provided by road operators, there is also a need for facilities at the time of intersection between pedestrians and other road user components. The other road user components are either non-motorized vehicle components (bicycles, pedicabs, delmans or the like) or motorized vehicles (cars, motorcycles or the like).

When there is an intersection between the two main components of this highway user, there is an increased risk for each user. The risk can be in the form of an accident involving the two components mentioned earlier that can result in injury, bodily disability to death.

In addition to the discussion related to security and safety issues for road users, there are also important matters in point 5 (justice) and 8 (togetherness and partnership). This is of course also a very important thing for road users, because if attention to this problem is lacking, then user satisfaction will also be in accordance with road operators.

To realize a sense of justice for road users, it needs to be regulated in such a way that each road user component gets a proportional right in accordance with needs. One example is when the government wants to increase public awareness to walk, the government must be prepared with the availability of facilities that can support this. The government must also have a high commitment in maintaining these facilities in good condition and utilized according to their functions.

The principle of justice must also always be held when there is an intersection between two components of the road user. For example, when road users will cross, in principle of fairness, it is necessary to provide adequate and safe crossing facilities

from other road users. The age and physical condition of the pedestrian crossing will also require the best balance in giving them a sense of justice and security. Adequate crossing times and the awareness of other users in giving away their rights must also always be a concern.

Awareness in utilizing road facilities is a matter that must be upheld by every road user. Every component of road users must have a sense of togetherness and partnership in utilizing road facilities. This will encourage mutual respect and provide comfort in utilizing road facilities.

In article 3 there is one of the objectives of the operation of the road which should be the government's main focus. This is to realize order and legal certainty in the operation of the road.

To realize this, the government must maintain, provide and monitor the utilization of the road facilities provided. This principle will be able to provide security and comfort in using road facilities. For example utilization of sidewalk facilities for pedestrians, vehicle users are not permitted to use them and when pedestrians use zebra crossing facilities, other road users must respect their rights and allow sufficient time to cross.

In the event of a violation of existing rules, the government must be able to provide legal certainty to the injured and violating parties. The availability of this tool will provide lessons for all of us in respecting the rights of other road users.

In Article 9 the status of the administration of public roads is explained. One of the interesting status of public roads is the existence of city roads (public roads in the secondary road network system that connects service centers within the city, connects service centers with parcels, connects between parcels, and connects between settlement centers within the city)

Urban conditions as the center of government and trade result in various components of road users being concentrated at a certain point. The high number of user components on a road can increase various risks to road users. Risks arising from the intense intensity of road users must be a priority to find solutions to reduce the amount of risk that exists.

In article 27 there are various things that need to be done by the government in conducting guidance on public roads, especially for city roads. One of the important developments for the government to do is to implement applied technology development activities on city roads. The existence of various facilities that are available now needs to be reviewed to assess the extent of the benefits and usefulness of these facilities. Does it meet expectations or needs?

Regulation of the Republic of Indonesia no. 34 year 2006 about road

To realize a good road, a technical plan must be made that takes into account the needs of pedestrian and disabled facilities (Article 86 paragraph 5). According to the explanation of Article 86 paragraph 5 caused by pedestrians and persons with disabilities need to be taken into account because it is part of the traffic. Pedestrian and disabled facilities are important modes of transportation, such as sidewalks and crossings on the road, on the road surface, and under the road.

The government is obliged to provide road equipment directly related to road users, including: (Explanation of Article 22 paragraph 3)

    a. the rules and prohibitions stated in APILL (Traffic Signs), signs and markers;

    b. instructions and warnings stated by signs and other signs; and / or

    c. pedestrian facilities on a designated road

Regulation of the Minister of Public Works of the Republic of Indonesia Number: 03 / PRT / M / 2014 concerning Guidelines for Planning, Provision and Utilization of Pedestrian Network Infrastructure and Facilities in Urban Areas

The government defines the term crossing as a facility that connects crossing pedestrian spaces.

Crossing type:

i. Field Crossing

    a) Zebra (there is an intersection with or without signal with vehicle speed <40km / hour)

    b) Pelicans (a minimum distance of 300m from an intersection, equipped with markers and traffic control lights with a vehicle speed> 40km / hour)

ii. Crossing not in one field

    a) Pedestrian Bridge

    b) Tunnel
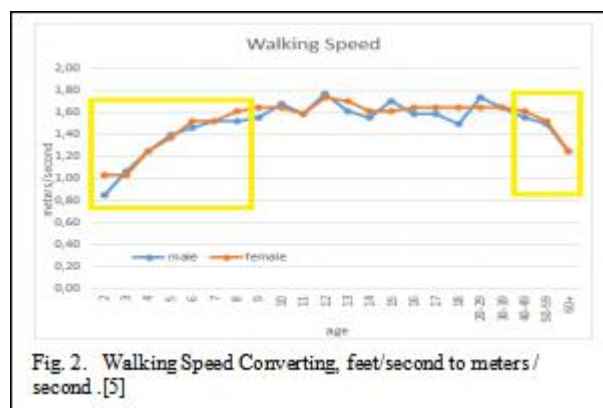
Walking Speed and Vehicle Braking Time

The availability of level road crossing facilities found on the highway requires a study of the magnitude of the variables used. This is to provide comfort for the waders in carrying out their activities.

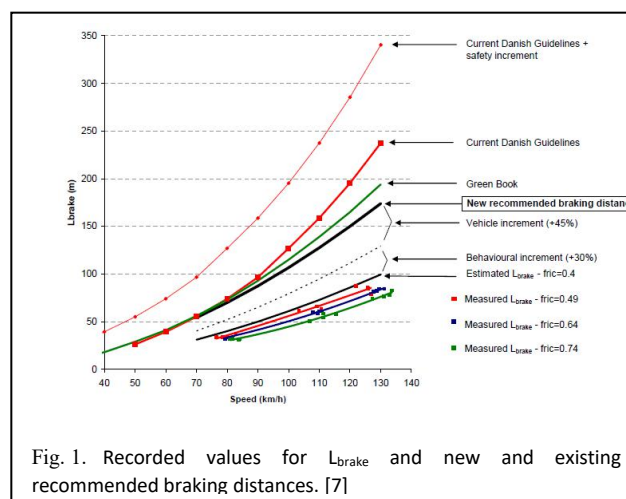| Age (years)	50th Percentile Walking Speed (ft/s)	
	Males	Females
2	2.8	3.4
3	3.5	3.4
4	4.1	4.1
5	4.6	4.5
6	4.8	5.0
7	5.0	5.0
8	5.0	5.3
9	5.1	5.4
10	5.5	5.4
11	5.2	5.2
12	5.8	5.7
13	5.3	5.6
14	5.1	5.3
15	5.6	5.3
16	5.2	5.4
17	5.2	5.4
18	4.9	N/A
20–29	5.7	5.4
30–39	5.4	5.4
40–49	5.1	5.3
50–59	4.9	5.0
60+	4.1	4.1

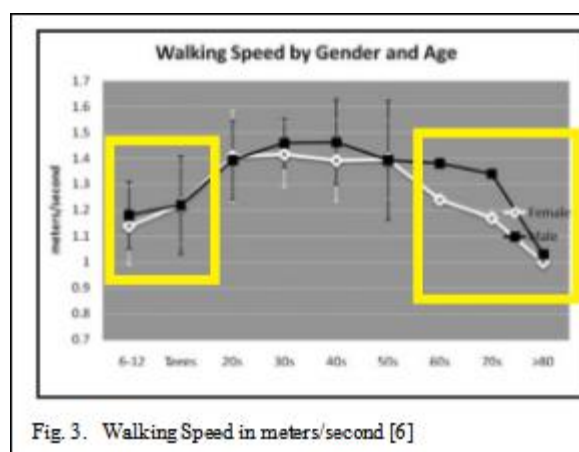Fig. 1. Walking Speed in feet/second [5]

Walking Speed

Activities carried out by pedestrians who use the highway. The ability to walk is largely determined by gender, age and disabilities owned by pedestrians (disability). In this study, 2 research references will be used which have been conducted previously related to normal human walking speed according to gender and age.

Fig. 2. Walking Speed Converting, feet/second to meters / second .[5]

Based on the results of research conducted can be seen the existence of fluctuations in human walking speed ability. The study distinguished variables between gender and age of pedestrians.

Fig. 1. Recorded values for L_{brake} and new and existing recommended braking distances. [7]

The results of the study in Fig.2 and Fig.8 can be seen, human walking speed tends to be stable at the age of 20-40 years. Walking speed will decrease significantly at the age of 50 and above. This fact needs attention in the preparation

Fig. 3. Walking Speed in meters/second [6]

Vehicle Braking Time

In general, almost all vehicles have brake facilities to stop the vehicle. The use of brakes requires a variety of careful calculations so that the vehicle can stop safely and comfortably. There are several important factors [7] that support brake capability, including 1) Speed, 2) coefficient of friction, 3) braking behavior / technique, 4) braking system and condition, 5) tires condition, 6) road's vertical grade. These factors must be a concern for vehicle users so that when they stop the vehicle they use can be adjusted to the needs.

$$l_{brake} = \frac{V^2}{2 \cdot g \cdot (\mu_{brake} + s) \cdot 3.6^2}$$

l_{brake} = braking distance (m)
V = speed (km/h)
g = acceleration due to gravity (9.81 m/s^2)
μ_{brake} = mean coefficient of friction
s = roadway grade

Fig. 2.   Methods to estimate braking distance. [7]

The above method (fig.4.) Can be used as a reference for the time needed to stop the vehicle moving in a safe condition.

In fig.5 above can be used as a reference how we can calculate the safe distance to start braking until the vehicle stops. Sudden or too hasty braking can result in the vehicle not being controlled properly and there may be a greater risk.

Fig. 3.   Jalan Waktukencana, Bandung, Indonesia (brown) dan

Ubiquitous Computing (UbiCom)

Is a concept that explains the ability of electronic components that are around us that are connected to one another and become supporters to provide convenience to humans [8].

The concept grows very fast along with the growth of mobile technology and IoT (Internet of Things). Almost all aspects of human life today have been touched and cannot be separated from various electronic technologies.

One electronic component that can support UbiCom is Arduino. Arduino is a microcontroller that was developed in an open-source system and supported by chips and various other components integrated in a small board. Arduino is like a general purpose micro controller that can be integrated with various sensors and can be programmed as needed.

III. Methodology

This research will be carried out by conducting a study of the existing rules and regulations relating to transportation and various facilities that should be provided and realization in the field, and conducting a study of the impact of the implementation carried out, by doing the following:

Literature review

Observations and interviews with stack holders

Problem analysis

IV. Research object

This study will examine crossing facilities provided by the city government of Bandung, West Java, Indonesia. There are 2 crossing facilities whose technology is used almost the same, but the study will focus on one of the crossing facilities that are located close to the Bandung mayor's office, precisely on Wastukencana road.

Fig. 4.   Phase 1 Push Button and Cross Request

Street Name	Street Specs*			Pedestrian Crossing Facility**				
				On Street			Above / Under Street	
	Material	Long (m)	Width(m)	Zebra Cross	Pelikan Cross		Bridge	Tunnel
					No Signal	With Signal		
Wastukencana	Aspal (Hotmix)	1400	12	4	3	1	1	NA

Fig. 5.   Road Facilities at Jalan Wastukencana

Street Condition

Wastukencana road (fig. 6), is a road that is in the middle of bandung city which has unique characteristics. The 1400m road is divided into 2 parts of one-way streets and 1 part of 2-way roads. This road was built with hotmix material, thus

making this road one of the highest quality roads in the city of Bandung. The object of observation is a pelican cross with signal found near the entrance of the mayor's office in Bandung (red circle). The nearest intersection is about 100m and vehicles that pass through this road vary greatly from private vehicles (2 and 4 wheel) and public vehicles.

The quality of the road is very good and one-way, making this road often passed by vehicles with speeds exceeding the speed limit of vehicles in the city. This is certainly very risky for other road users. High speed will require a long time to stop the vehicle when there are pedestrians who want to cross the road which reaches 12m wide. Of course this certainly requires high awareness from motorists to be able to provide opportunities and adequate time for pedestrians to cross.

The data contained in fig.7 provides an overview of the number of crossing facilities found along the Wastukencana road. A total of 9 crossing points, there are 3 crossing pelican crossing types which have a high enough risk because their existence is not supported by signal markers for other motorists. This of course requires attention from the party organizing the road.

Pedestrian Crossing with signal

The existence of pelican crossing pedestrian crossing on the wastukencana road is certainly expected to provide safety and comfort for crossers when crossing the road. Road conditions are quite congested because it is close to the Bandung mayor's office and several offices and mosques need special attention when crossing.

Based on the results of interviews conducted with Transportation Department officials when observing, the presence of pedestrian crossing with signal can provide a sense of security and comfort from road pedestrians, but there are still deficiencies in terms of order of motorists in obeying the time or signal which are given. But in general the implementation of this technology was felt to be quite good for the impact of road users, especially pedestrians.

Basically, pedestrian crossing with signal, has 2 phases, which is

Phase 1 Push Button and Crossing Request

Road crossers who will use this facility will press the request button located on one of the poles on the side of the road (fig.8). The system will capture requests to cross and calculate the lag time with the previous crosser. If deemed sufficient, the system will give a signal to motorists to reduce their speed and do a count down from 3 to 0. Then after the value is 0, then the system will send a notification to the waders to be able to cross.

Phase 2 Cross Road

After notification to cross the pedestrian, the system will automatically count down from 11-0 (fig 9.). Then, if it has a value of 0, then the system will turn on a green light as a sign to allow the road for driver.

The time given by the pelican crossing with signal is of fixed value, 11 seconds. There is no choice of physical condition of the pedestrian. This is certainly not a problem for adults who have normal physical conditions. But it can be imagined if those who want to cross are children, elderly people or people with disabilities, we can be sure that the time of 11 seconds is very less for them.
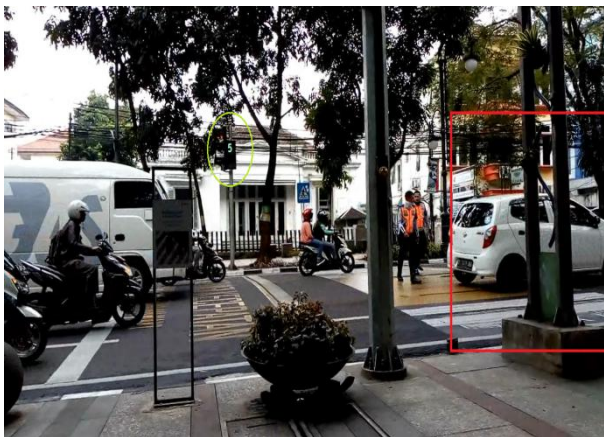
Fig. 6.   Phase 2 Cross over

Fig. 7.   Phase 2 Cross Road Low respect to pedestrian

V.   Conclusion and Suggestion

The existence of supporting facilities located on the highway, especially those intended for pedestrians, is very important to maintain safety and comfort and reduce the risk of accidents. But in its implementation there are still some shortcomings that need to be improved

Conclusion

Observations made on the existence of facilities that are located along the Wastukencana road, especially facilities for pedestrians, obtained the following results:

1)   The availability of crossing facilities needs to be reviewed both in quantity (distance between facilities), because if the distance between facilities is too far away, it is probable that pedestrians if they want to cross the road are misplaced. In addition, no less important than the quantity is the availability of supporting facilities that can provide a sense of security and comfort for road users. Increasing the usual crossing facilities to become pedestrian crossing

with signal will certainly be able to increase user safety and comfort. In addition, road users need to be educated about how to respect the rights of other road users, as in Fig. 10.

2) The facilities currently available for pelican crossing with signal are limited to only 1 crossing selection button (with 11 seconds for all waders including children, elderly and disabled) and sound and light signals. This technology needs to be reviewed to be able to provide special facilities for people with different physical conditions. Besides the signal signals that are given also need to be distinguished to increase the level of alertness of other road users.

Suggestion

The results of this research will be a reference for the next research, by developing to improve the facilities of the pelican cross system that has been applied at this time. The development of the system will lead to the application of the concept of Ubiquitous Computing (UbiCom) by utilizing an Arduino microcontroller that has good capabilities and can be integrated with various sensors.

Providing choice facilities for several different physical according to needs (children, elderly, and people with disabilities), so as to provide proportional time for road waders.

The system can cross-check the existence of crossing-off road to cross

Detect existing environmental conditions (dry / rainy) and provide an appropriate time period for motorists to be able to stop safely and comfortably. This of course will also be able to increase the safety and comfort of road crossers.

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