Applying Facial And Age Group Identification Technology to Optimize Crossing Light Duration at Zebra Crossings

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FOREWORD

With the current scope of road safety, there is one aspect sometimes still overlooked which is pedestrian safety on the roads. This is especially prevalent when certain demographics use the zebra crossing facility which is widely used. The result of this is that demographics such as the elderly, kids, and the disabled may have difficulties in crossing zebra crosses safely especially under certain conditions such as when multiple vehicles are passing through at a high speed. This provides a dangerous environment for these demographics to cross through as they aren't able to cross at the safe velocity of 1.2 m/s which means that they need more time than the average time provided by the traffic light when it is red for vehicles.

A potential solution drawn up for this problem is by applying cameras with biometrical and object detection. By applying this technology, more crossing time can be provided for demographics such as the elderly, kids, and the disabled. This would make a safer environment for these demographics as they are given more time to cross when they are identified by the cameras. This will give cars with a heads up through the traffic lights being red for a longer period of time compared to the average.

The researchers of this project would like to give gratitude for the following people who have helped in devising the idea for the solution stated above through directly or indirectly through consultation and guidance:

- **Our Research Tutor, Mr Stefanus Setiawan**, for the invaluable guidance provided through consultation and discussion which helped in expanding and fine tuning the current idea.

At the end of this research project, hopefully a solution or suggestions can be contributed. This can be in the form of the prototype of the system, the results of testing the prototype, or through the analysis of all those aspects.

CHAPTER I
BACKGROUND

1.1 Background

Safety while traveling is paramount and prioritized, using various transportation methods. Whether as pedestrians or car drivers, everyone aims to reach their destination safely. One innovative solution for road safety, especially for pedestrians to cross safely, is the zebra crossing. This simple facility is relatively easy to implement on roads in general, and there are already many zebra crossings on most public roads.

However, zebra crossings still have shortcomings. Despite their presence, one drawback is the difficulty pedestrians face in crossing them when there is heavy traffic moving at high speeds and no vehicles stop. When many vehicles are swiftly passing by and unwilling to stop, pedestrians may not feel safe using these facilities. This is evidenced by research analyzing pedestrians' attitudes toward using zebra crossings, where only 20 percent of pedestrians in the Malioboro Yogyakarta area utilize zebra crossings (Trianingsih & Hidayah, 2014). Based on the same research and sample, 80 percent of pedestrians in the Malioboro Yogyakarta area feel uncomfortable using zebra crossings (Trianingsih & Hidayah, 2014).

Another example can be observed at the entrance gate of the Santa Laurensia school's motorcycle parking lot. During school hours, from around 6:30-7:10 in the morning and during the pickup time for elementary to high school students from 1:00 in the afternoon to 4:00 in the evening, traffic congestion occurs due to the density of vehicles on the road, making it difficult for pedestrians to cross the zebra crossing.

This issue can be addressed by implementing traffic lights at zebra crossings prone to heavy traffic. This has also been implemented in Indonesia on some streets such as those in Alam Sutera. However, there are still shortcomings due to the unsupportive attitudes of car drivers. A case study on Pedestrian Safety and Driver Yielding Near Public Transit Stops at sixteen zebra crossings in Saint Paul, Minnesota, showed that only 32.75% of drivers yielded to allow pedestrians to cross. This is supported by research conducted on the Wonosari roads, where the results showed that not a single car or motorcycle gave way for pedestrians to cross the zebra crossing (Poei & Ansusanto, 2016).

Another factor affecting pedestrian safety is the walking speed of pedestrians crossing the zebra crossing. This refers to factors that hinder people's ability to cross the zebra crossing safely because they walk too slowly. This is supported by information in the book "Pedestrian Facilities" which states that demographics most at risk when crossing zebra crossings are children, the elderly, and people with disabilities as they have difficulties crossing at a relatively safe speed of 1.2 meters per second (Tanan, 2011, 29). Therefore, these demographics are considered vulnerable due to the factors mentioned.

As a result of the aforementioned issues, pedestrians become victims of traffic accidents. This is evident from WHO statistics stating that there are about 270,000 pedestrian deaths per year due to traffic accidents, accounting for 22% of traffic accident victims (Wicaksono et al., 2021). In Indonesia, at least 15 percent of pedestrian accidents occur, but it can be estimated that there are more unreported accidents, potentially approaching 50 percent (*Keselamatan Pejalan Kaki Dan Pesepeda*, 2016). Hence, there is a need for innovation in these facilities to provide a safer experience for pedestrians.

From the identified weaknesses in previous facilities and technologies, there could be advancements to make zebra crossings safer for pedestrians. The proposed method to address the issues above is through the use of cameras that can identify the number and age groups of people waiting and adjust the crossing time accordingly, prioritizing vulnerable demographics such as children, the elderly, and people with disabilities. This system is proposed because camera identification technology is already used in other fields for various purposes. Examples include the facial biometric payment system used in Japan for public transportation payments (Borak, 2023).

1.2 Problem Statement

The zebra crossing facilities in today's era, even though equipped with traffic lights to assist in controlling which party can pass, still have shortcomings. These shortcomings are prevalent when the road with the zebra crossing is crowded with vehicles moving at high speeds. This is because with the high number of vehicles moving fast, it makes crossing a zebra cross difficult for pedestrians as there is a shorter time frame to pass as vehicles can disregard the light color from the traffic lights. This is particularly evident in zebra crossings that do not have traffic lights. The result of this is that certain demographics such as children, the elderly, and people with disabilities are also quite vulnerable when crossing the zebra crossing.

Cameras using a system to identify the number of people and their ages have the potential to minimize vulnerabilities for demographics such as children, the elderly, and people with disabilities. This is because the system can categorize people based on demographics and conditions. Based on the categorized information, these more vulnerable individuals will be prioritized to cross the zebra crossing by adjusting the predicted time required.

1.3 Research Question

Based on the problem statement above, the research questions that could be posed are:

1. How can a camera system be developed to identify the number and age groups of people for traffic lights?

2. What are the steps required to test the accuracy of the Facial Recognition and Age Group Camera System?

1.4 Research Objective

The objectives of this research are:

1. To develop a camera system that can identify the number and age groups of people for traffic lights and adjust the time provided for crossing accordingly.
2. To test the accuracy of the Facial Recognition and Age Group Identification Camera System.

1.5 Benefit of Research

Theoretical benefits of conducting this research include the advancement of facial and age detection technology application.

Practical benefits of this research lie in aiding the innovation of pedestrian facilities to be safer and more comfortable for all demographics. Additionally, it provides an easily implementable solution that could be cost-effective and time-saving.

CHAPTER II
LITERATURE REVIEW

2.1 Biometrics and Object Detection System

Biometric and object detection systems are a relatively recent technology application. For a face identification system, it can be described as a 1:N matching problem because the system compares faces captured by the camera with a face database (Taskiran et al., 2020). This system is identified through the displayed screen with a bounding box as the marker, and with this system, all identified faces are placed within their respective bounding boxes (Taskiran et al., 2020). In the database, a large number of face photos are needed so that the artificial intelligence used can be trained for face identification, and with more training, face identification can be done more accurately (Ibrahim & Saleh, 2008). Then for identification itself, a face can be identified through facial markers such as eye corners, eyebrows, lips, and nose tips (Taskiran et al., 2020). From these facial features, age group identification can also be performed (Wibowo & Karmilasari, 2017). Object detection meanwhile is also done through a similar manner in which facial detection is done. Specifically by using a fuzzy control system based on fuzzy logic mathematical systems that analyze input values in terms of logical variables that take on continuous values between 0 and 1 (Kumar, 2020). Fuzzy logic itself is based on the observation from which people make decisions based on imprecise and non numerical information, so as a result these models have the capacity to represent the impreciseness of non-numerical information (Kumar, 2020). As a result, this concept can be applied to a live camera feed where objects might not look like what it is due to image quality, lighting, position, etc, so this model can be used to accurately identify uncertain objects based on video feed (Khairudin et al., 2021). The systems stated before have a lot of potential to be applied in various fields, one of which is in traffic security. This is because with biometric identification and object detection, an intelligent system can be created. By intelligence, it means that the system can make decisions that can make adjustments or adapt based on the information received from artificial intelligence analysis of the given situation.

2.2 Raspberry Pi Model 4B

The Raspberry Pi Model 4B is one of the Single Board Computers (SBC) created by Raspberry Pi. This Single Board Computer is a development board commonly used for prototypes and electronic projects. The Raspberry Pi Model 4B features the Broadcom BCM2711 Quad-core Cortex-A72 (ARM v8) 64-bit SoC microprocessor with a frequency of 1.8GHz capable of running a simplified Linux Operating System (Przemysław Łagód, 2023). The face identification program will be executed within the Linux system. The Raspberry Pi Model 4B is suitable for this project due to its satisfactory performance in object recognition and its compact size. Furthermore, the Raspberry Pi Model 4B is supported by a wide range of electronic accessories and software. It also comes with comprehensive documentation, and numerous projects have been built using the Raspberry Pi Model 4B as the base. One of the features of the Raspberry Pi

Model 4B is the MIPI CSI-2 v1.1 with 2 lanes, which allows direct connection to the camera to be used (Raspberry Pi, 2019).

2.3 Camera

The camera is one of the sensors used to perceive the surroundings of a device. The camera sensor captures light reflected from objects through the camera lens. Light entering the camera lens then strikes the camera sensor. The camera sensor consists of a set of small sensors capable of receiving information in the form of RGB values, which stand for Red, Green, and Blue, and then processing them together to capture external perceptions in a 2-dimensional image (Amrullah, 2011). This image information is then transferred to the Raspberry Pi for further use. The camera module used in the Face and Age Group Identification Camera System will have a MIPI CSI-2 to be connected to the system.

2.4 MIPI Camera Serial Interface 2

MIPI Camera Serial Interface 2 or the MIPI CSI-2 is an interface standard developed by the MIPI Alliance that aims to create a standard specifications for the mobile ecosystem (*MIPI Alliance Specification for Camera Serial Interface 2 (CSI-2)*, 2009), in the MIPI CSI-2's case, this standard was developed to connect a peripheral device, a camera in particular, to a host processor, the hardware and software that performs core functions for telecommunications and application tasks (*MIPI Alliance Specification for Camera Serial Interface 2 (CSI-2)*, 2009). The interface was developed as a means to fulfill the demands of increasingly higher image resolution that requires much larger bandwidth capacity of at that time, host processor to camera interface. A serial interface is used, as opposed to a parallel interface as parallel interfaces are difficult to scale, require many physical connections and consume a relatively larger amount of power (*MIPI Alliance Specification for Camera Serial Interface 2 (CSI-2)*, 2009). The CSI-2 is a mobile industry standard, robust, scalable, low-power, high-speed, cost-effective interface that supports a wide range of imaging solutions for mobile devices (*MIPI Alliance Specification for Camera Serial Interface 2 (CSI-2)*, 2009). The MIPI CSI-2 has a theoretical maximum of 800 Mbps of throughput per lane, with a configurable 1 to 4 connecting lanes (`7). The raspberry pi model 4B has only 2 accessible lanes (*Buy a Raspberry Pi 4 Model B – Raspberry Pi*, 2019).

2.5 Relay

A relay is an electronic component that functions as a switch. Relays can be operated using an electric current. A relay consists of two parts: an electromagnet coil and a mechanical switch that utilizes electromagnetic principles to move the switch (Misel, 2022). The relay will only activate when electric current flows through it. Relays are used for this project to control traffic lights digitally using a microcontroller.

2.6 Traffic Lights

Traffic lights are an essential element for traffic regulation. Traffic lights have a circuit categorized as parallel that alternates (Erick, 2022). The meaning of this is that when the red light is on, the other lights are off, and this is due to the cutting off of the current to the lights that should not be on. Additionally, traffic lights can be divided into two categories based on their operation, fixed time traffic signals, and actuated traffic signals (*PENGANTAR TEKNIK TRANSPORTASI*, 2015). The difference between the two systems mainly lies in the timing settings. In fixed time traffic signals, the waiting and green times are predetermined and do not change based on conditions, but in actuated traffic signals, the waiting and green times can change over time based on vehicle arrivals at intersections (*PENGANTAR TEKNIK TRANSPORTASI*, 2015). Besides these two systems, there is innovation with fuzzy logic technology . Fuzzy logic technology can regulate the duration of traffic lights based on the volume of vehicles queuing (*PENGANTAR TEKNIK TRANSPORTASI*, 2015).

CHAPTER III
METHODOLOGY

3.1 Duration of Research

The time needed for this research project from the creation of the proposal to the final report is 5 Months lasting from January to May.

3.2 Description of Research Method

The creation of the system will be done first, this will be done by first assembling all hardware components such as the Raspberry pi 4B, camera, relay, and a light circuit assembly. After this assembly, coding in the AI model into the Raspberry pi 4B will be done in order for it to be connected with the camera and get a live feed from it. Then testing of the system will be conducted where the accuracy of the facial recognition and age group identification identification will be the main variables observed. The scope of testing will be by using a different amount of people present in the camera view, age groups of those people. To obtain fair results, the light exposure, camera position or angle, and relative face position to camera while testing must remain consistent.

3.3 Research Variable

3.3.1 Dependent variable in the testing:

- Accuracy of the facial recognition and age group identification identification of the Facial Recognition and Age Group Identification Camera System compared with the live feed from the camera.

3.3.2 Independent variables in the testing:

- Number of people (in the camera view)
- Age group of people

3.3.3 Controlled variables in the testing:

- Brightness/light exposure
- Camera position/angle during the testing process.
- Relative face position to the camera

3.4 Tools and Materials

Tools

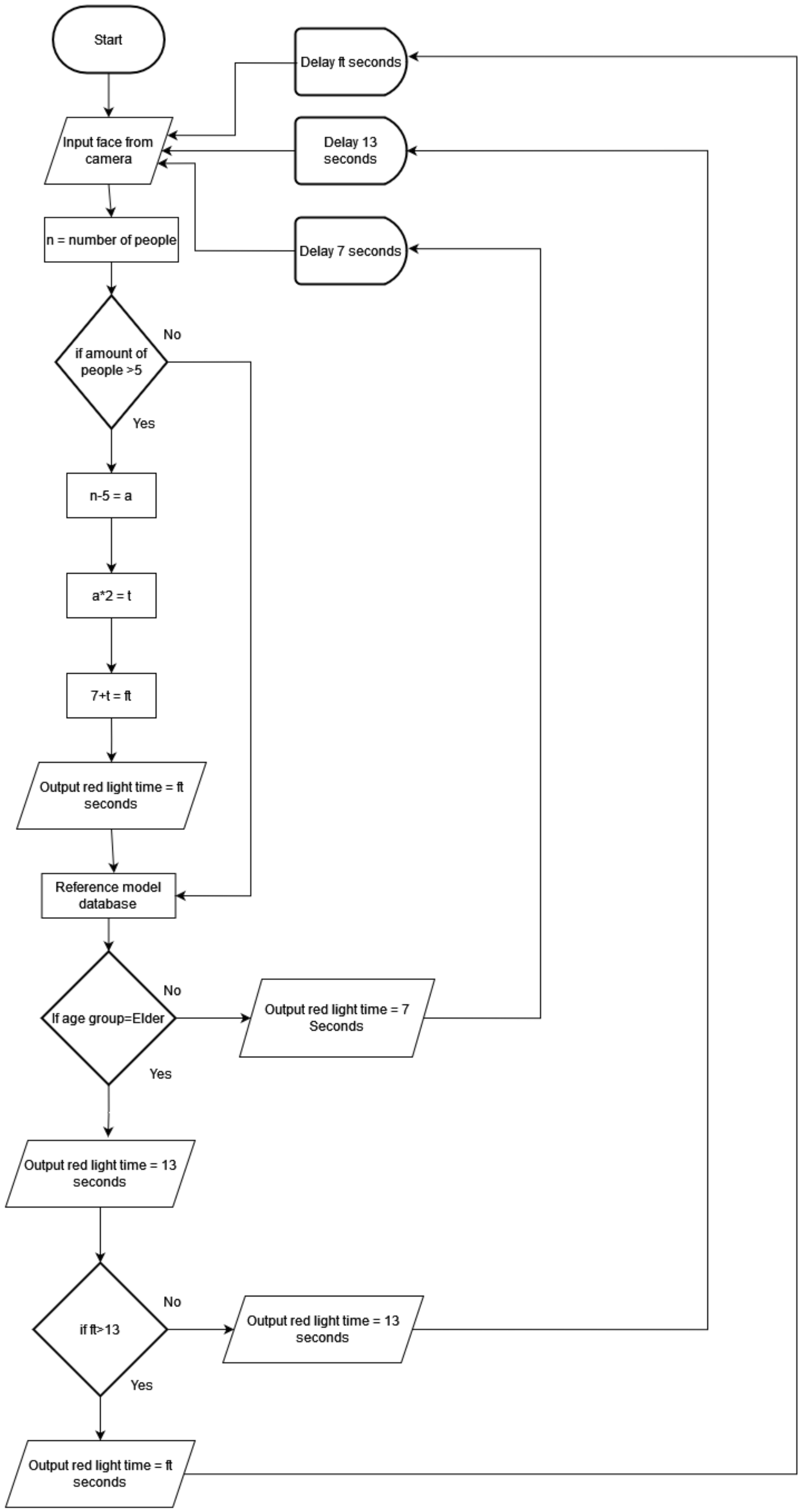
- Mouse
- Keyboard

- Screwdriver
- Soldering iron

Materials:

- Raspberry Pi 4B
- Camera with MIPI CSI interface
- Relay
- Light circuit assembly (for traffic lights)
- Cables
- Solder wire

3.5 Research Stages



3.6 Procedure

3.6.1 Assembling hardware with a camera device connected to a Raspberry Pi

1. Insert the MicroSD card in the MicroSD card slot of the Raspberry Pi
2. Plug in the ribbon cables of the Camera Module on to the MIPI CSI port of the Raspberry Pi
3. Connect the relays on the GPIO header of the Raspberry Pi
4. Connect the relays to the traffic light

3.6.2 Implementing facial and age group identification software in the Raspberry Pi

1. Install Raspberry Pi OS on the Raspberry Pi Model 4B's MicroSD card
2. Install a object recognition model that suits the application
3. Program a code that activates the relays whenever it detects humans on the camera
4. Relay activation will be determined based on the age group of the human

3.6.3 Testing the facial and age group identification

1. Collect images of individuals and groups of people with varying ages.
2. Testing the accuracy of the system by pointing the webcam to a 24" monitor.
3. Display the collected image to the 24" monitor
4. Take a screenshot to note down whether the model detects the person, and if so whether the person or the group of people are considered inside the age group.
5. Repeat steps 2, 3, and 4 with different collected images.

3.6.4 Analyzing results from the testing of the facial, age group and identification

1. Arrange the results of the camera identification and actual live feed data in a table.
2. Compare each test result from the system with a photo of the actual live feed from the camera by assessing the differences in the amount of people, age group of the people.

Example of table used:

Amount of people	Actual age and age group	Age group identified from camera
Person 1		
Person 2		
Person 3		
Person 4		
	Total amount of people Identified	

Amount of people	Actual age and age group	Age group identified from camera
	Time allotted	

CHAPTER IV
DATA AND ANALYSIS

4.1 Data

4.1.1 Trial 1

4.1.1.1 One person

Amount of people (1)	Actual age and age group	Age group identified from camera
Person 1	4 years old (Child)	Child
	Total amount of people Identified	1
	Time allotted	7 Seconds

4.1.1.2 Multiple people of same age group

Amount of people (3)	Actual age and age group	Age group identified from camera
Person 1	5 years old (Child)	Child
Person 2	5 years old (Child)	Child
Person 3	5 years old (Child)	Child
	Total amount of people Identified	3
	Time allotted	7 Seconds

4.1.1.3 Multiple people of different age group

Amount of people (3)	Actual age and age group	Age group identified from camera
Person 1	44 years old (Adult)	(Failed to identify)
Person 2	11 years old (Child)	Teen
Person 3	42 years old (Adult)	Adult
	Total amount of people Identified	2
	Time allotted	7 Seconds

In the first trial, there is one instance of failure to identify a facial feature and one other instance where the age group identified was inaccurate. This was only in the multiple people of different age groups test. In this case a 11 year old child was identified as a teen, meanwhile an adult of 44 years of age was not identified. As the 13 years old is the beginning of the teen age group, this inaccuracy of identifying a 11 year old as a teen is not a very drastic error. The rest of the results for the age group obtained are accurate with the real age and age group.

4.1.2 Trial 2

4.1.2.1 One person

Amount of people (1)	Actual age and age group	Age group identified from camera
Person 1	16 years old (Teen)	Teen
	Total amount of people Identified	1
	Time allotted	7 Seconds

4.1.2.2 Multiple people of same age group

Amount of people (2)	Actual age and age group	Age group identified from camera
Person 1	61 years old (Elderly)	Elderly
Person 2	64 years old (Elderly)	Elderly
	Total amount of people Identified	2
	Time allotted	13 Seconds

4.1.2.3 Multiple people of different age group

Amount of people (2)	Actual age and age group	Age group identified from camera
Person 1	22 years old (Adult)	Adult
Person 2	53 years old (Elderly)	Adult
	Total amount of people Identified	2
	Time allotted	7 Seconds

In the second trial, only one instance where the age group identification was inaccurate. This was in the multiple people with different age groups test group where a 53 year old elderly person who was identified as an adult. As 46 is the beginning of the elderly age group and anything below that is within the adult age group, this inaccuracy can be categorized as drastic. The rest of the results for the age group obtained are accurate with the real age and age group.

4.1.3 Trial 3

4.1.3.1 One person

Amount of people (1)	Actual age and age group	Age group identified from camera
Person 1	47 years old (Elderly)	Teen
	Total amount of people Identified	1
	Time allotted	7 Seconds

4.1.3.2 Multiple people of same age group

Amount of people (3)	Actual age and age group	Age group identified from camera
Person 1	39 years old (Adult)	Adult
Person 2	37 years old (Adult)	Adult
Person 3	40 years old (Adult)	Adult
	Total amount of people Identified	3
	Time allotted	7 Seconds

4.1.3.3 Multiple people of different age group

Amount of people (2)	Actual age and age group	Age group identified from camera
Person 1	67 years old (Elderly)	Elderly
Person 2	44 years old (Adult)	Elderly
	Total amount of people Identified	2
	Time allotted	13 Seconds

In the third trial, there are 2 instances where the age group was identified incorrectly. These two instances are a 47 year old elderly identified as a teen which was in the one person test group, and a 44 year old adult identified as an elderly person which was in the multiple people different age group test group. In the instance where a 47 year old elderly person was identified as a teen the inaccuracy is quite drastic considering the teen age group ends at 19 years old. Meanwhile, where the 44 year old adult was identified as an elderly person, this is still more accurate as the lower limit for identifying a elder is 46 years old and this difference is not too drastic. The rest of the results for the age group obtained are accurate with the real age and age group.

Child: 4-11

Teen: 12-19
Adult: 20-45
Elderly: 46-75

4.2 Analysis

From all three trials, the multiple people with different age group test groups was the one most susceptible to identifying an age group incorrectly. Causes for the inaccuracy in age group identification could be a result of the facial features of the people chosen. This is because facial features such as eye corners, eyebrows, lips, nose tips, and facial bone structure are the main factor of obtaining an estimate on age group as these are the main factors identified and used as reference by the AI model. These features would be different for each person, so certain features which give the impression of a younger age would result in a younger age group prediction and features which are present in older aged people would result in an older age group prediction.

Another factor could be the brightness of the screen, as this test was done by using pictures on a monitor set at the lowest brightness setting. As facial features aren't as defined if the brightness is still too high, the system will struggle to identify the facial features and as a result not identify a face at all.

So as a result, testing using real people instead of images displayed on a screen could reduce the likeliness of a face not being identified. However, for the system itself, the only plausible and assured method of increasing accuracy of age group identification is to train the model with a higher variety of people with different facial features. By training the model with higher varieties of people, it provides the model with more precise information on what ages have which type of facial features.

CHAPTER V
CONCLUSION

5.1 Conclusion

- Development of a system where a camera can identify age groups and in turn can be used to control how long a red light is on was successful.

- Testing of the camera system also yielded mostly accurate results with only one instance where facial identification failed entirely and only four other instances where age group recognition was inaccurate. Therefore it can be concluded that the camera system is quite accurate and can be a possible solution for zebra cross safety.

5.2 Suggestions

Some possible suggestions are using more powerful hardware for faster identification and a better resolution camera so identification can be done at longer distances. Another possible having some other features that are identifiable such as disabilities through identifying a wheelchair, walking sticks, and et cetera.

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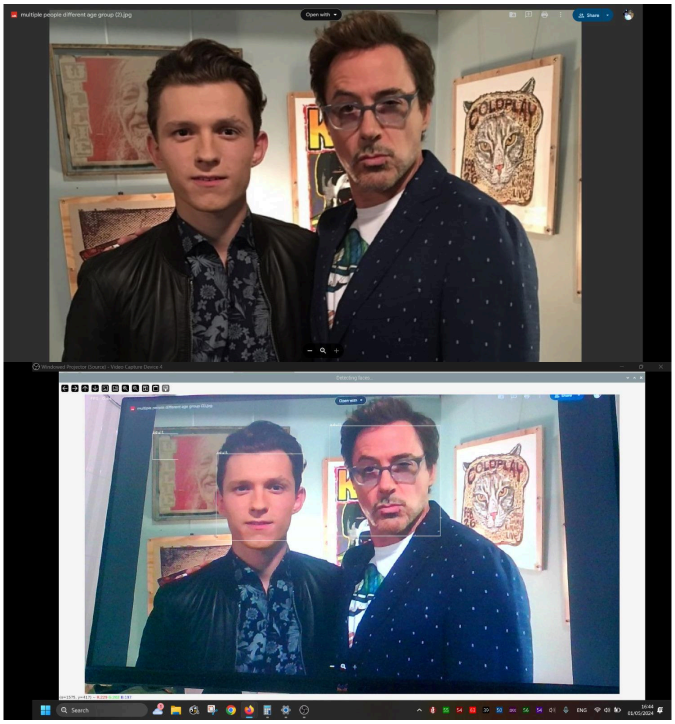
Appendix

Picture for 4.1.2.3 Multiple people of different age group

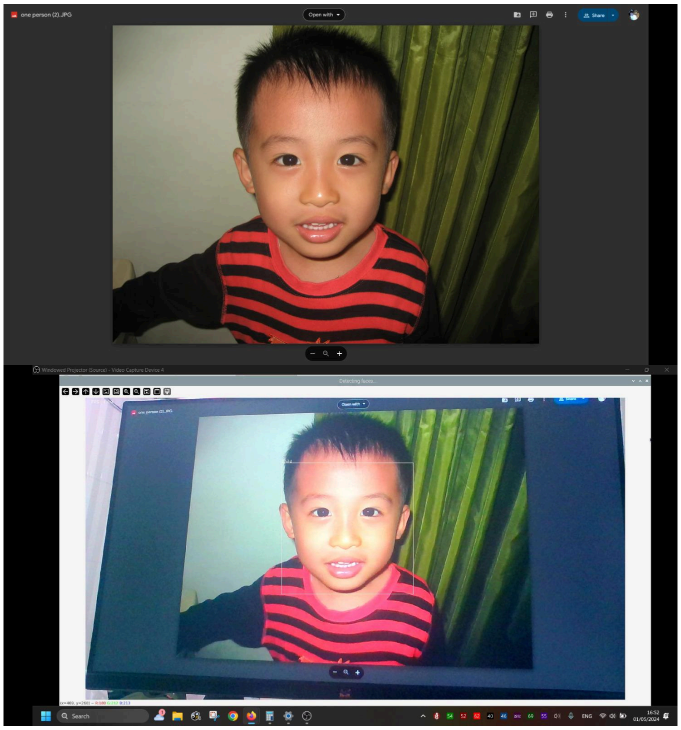


Picture for 4.1.3.1 One Person

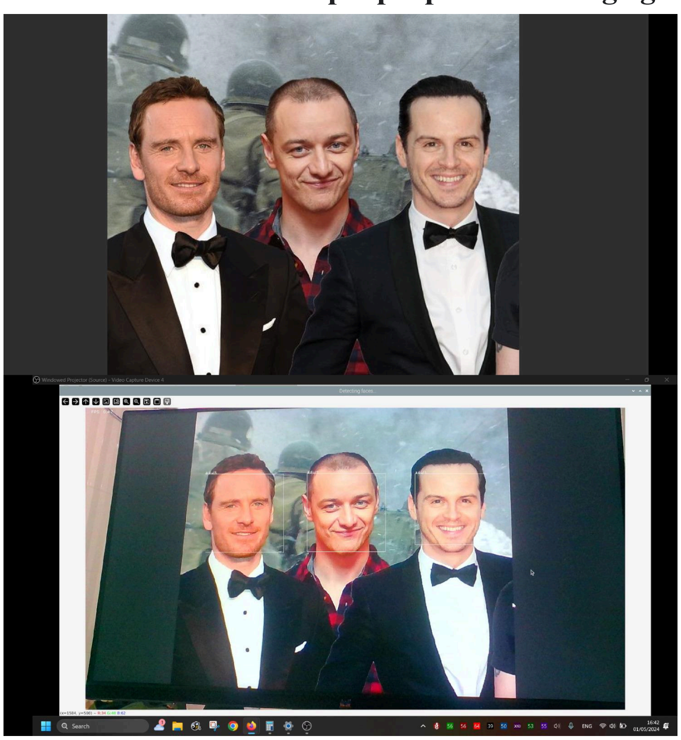
Picture for 4.1.1.3 Multiple people of different age group

Picture for 4.1.1.2 Multiple people of same age group

Picture for 4.1.1.1 One Person

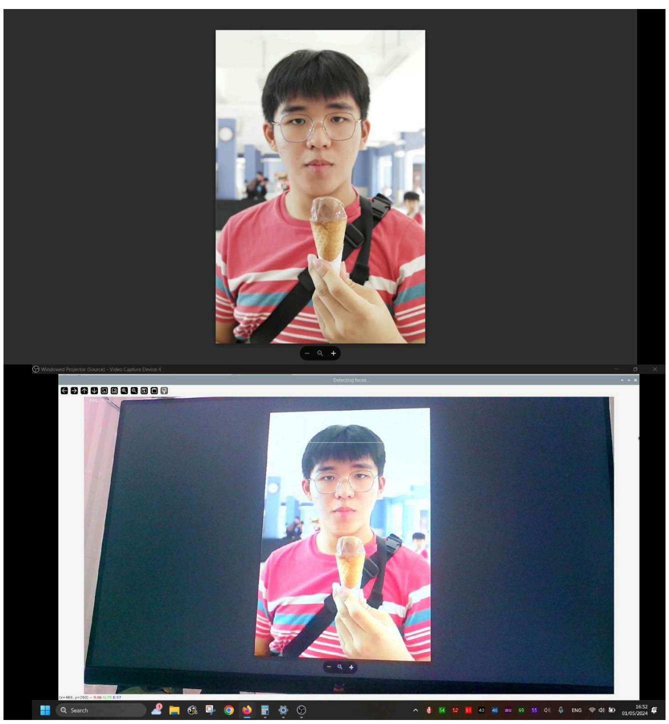


Picture for 4.1.3.2 Multiple people of same age group



Picture for 4.1.2.2 Multiple people of same age group

Picture for 4.1.2.1 One Person



Picture for 4.1.3.3 Multiple people of same age group