Automatic high speed photography based microcontroller

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Abstract. High-Speed Photography is a technique to capture a moment that moves very quickly. This technique is commonly used by photographers and scientists for research purposes, especially in the fields of physics, chemistry, and metallurgy. To capture the moment that moves quickly the photographer must squeeze the camera manually, then the camera will tend to shake, and the picture is not taken correctly. Also, there is also a delay between squeezing the camera with the shutter movement that adds error factor. In this study designed a high-speed automatic photography tool using a sound sensor that can freeze objects automatically when the sound is heard. To design and make this High-Speed Photography tool automatically use Microcontroller and FC-04 Voice Sound. The results of the overall test conducted to test all the components contained in the tool High-speed automatic photography. The first test scenario is to put the tool ± 50 cm will work optimally, the second test scenario is the sound sensor response when the balloon object to distinguish the object to photograph. This tool is capable of taking pictures automatically when the sound is heard.

1. Introduction
In this modernized world, the development of photography is rapidly increased and recently photography has used digital technology of DSLR cameras, that the users do not need to wash the films anymore. Photography is not only for the professionals or wealthy people, because the price of a camera is available for the society itself.

The term of photography comes from the word photos (light) and graphos (to note/to print) [1]. Literally, photography means as to print with the light. Photography is an art to print the object through camera that can communicate message or meaning through a photo. Photography is not only about camera, print an object and push the shutter button [2]. Without light, it is impossible to produce a good art of photograph. The type of photo that can be categorized as a good photo need to have a strong idea or concept of lighting, composition, and accuracy [3].

Photography is one word with various meanings and genres [4]. The uniqueness lies in every genre that has their own particular sign in every photo. There are several genres and types of photography includes in general patterns and have constant followers such as documentary photography, fashion photography, fine art photography, landscape photography, wedding photography, high speed photography, etc. The manual use of shutter or flash can be changed by having a shoot with high speed technology is included in one of the high speed photography. Shutter is known as an easy step to produce photo, but it becomes difficult by combining it with high speed photography. It is a speed camera to capture the moment, when the speed of a shutter is 1/4000 seconds, it produces frozen object, but if the
speed of a shutter is slow – for example 1 second – then the object will blur. Besides that, the focal plane shutter of a camera has a small slot that move slower (1/250), so that it exposes different parts of photography in different times [5,6].

When using high speed photography with a shutter, error can be easily made because we need to press the button exactly when the moment appeared. Moreover, there is also delay between when press the button of a camera with moving the shutter will increase the error factor. When pressing the camera manually, then the camera will be unsteady and the photo is not perfectly taken. With manual method, the shutter will be wasted, because many photos are not suitable for the photographer’s wishes so that photo session can be done repeatedly.

From this reason, I design a high-speed automatic photography tool using a sound sensor that can produce photos easier in High Speed Photography, especially the fast-moving object.

This tool can freeze object automatically when sound is heard. For example, in taking photo of a blast of a balloon, this tool will automatically take shoots when the sound of a blast is heard. With the high speed photography, we can have good photos with high speed and do not waste the shutter. The function of this tool is to help produce a good picture in high speed and the result of the photo can be sold in website or exhibition that can promote the product of the photography.

2. Theoretical basis

2.1. The history of photography

The term of photography comes from the word photos (light) and graphos (to note/to print) (1). Literally, photography means as to print with the light. Photography is an art to print the object through camera that can communicate message or meaning through a photo. Photography is not only about camera, print an object and push the shutter button. Without light, it is impossible to produce a good art of photography. The type of photo that can be categorized as a good photo need to have a strong idea or concept of lighting, composition, and accuracy [3].

2.2. Single-lens reflex (SLR) camera

Single-lens reflex (SLR) camera is a camera that use single line lens system for passing the lighting to the two places - Focal Plane and Viewfinder – so that to make the photographer to look at the object through camera as the same as the result of the photo. The result of this photo is different with non-SLR, where the photo in the viewfinder can be seen differently than in the film, because this camera is using two line lenses system – one to go through the light to viewfinder, and the other one is through the light to focal plane [3,7].

SLR camera is using pentaprism that is placed in the upper optical path through lens to the film. The light that comes in will reflected upwards by reflective mirror glass and collide with pentaprism. The pentaprism then reflects the light several times until it hit the viewfinder. When the button is released, the mirror will lead the light to the film [7,8].

![Figure 1. SLR camera.](image-url)
2.3. High speed photography
High Speed Photography is a technique to capture a moment that moves fast. This technique can be used by scientist for scientific research especially in physic, chemistry, metallurgy, etc. The high speed technique basically has two main factors, that are [9-11]:

- Highly exposure speed. High Speed Photography is needed exposure speed more than 1/10.000 until 1/100.000. The high exposure speed cannot be done by ordinary DSLR and it only can be done by using special instrument.

The accuracy of moment exposure. The accuracy of moment exposure is the power of HSP. For scientific research, moment exposure can be calculated with complicated quantification and supported by updated instruments.

2.4. High speed photography technology by using DSLR
The speed of exposure in DSLR camera in this recent time is only 1/8000. With the speed shutter, the usage of normal flash cannot compensate the speed shutter. If it is forced to be taken, then there will be a black spot in some part of a photo because of the shutter unit has been closed before the shutter turn off the lights [9-11].

The example of High Speed Photography technique:

![Figure 2. High speed break the bottle.](image)

The technique of photography for freezing the object is named as freezing or simply put it as catching the movement from an object. By this technique we can see the things that normal eyes cannot see. Figure 2 is the moment that use high speed for breaking the bottle and picture 3 is the moment where a can as an object was destroyed.

![Figure 3. High speed destroying a can.](image)

2.5. Microcontroller
Microcontroller is a Single Chip Microcomputer that has a Control Processing Unit where it can be combined with I/O (Input/ Output) units and RAM (Random Access Memory) and ROM (Read Only Memory) in one chip [12,13].
2.6. Microcontroller ATmega328
Microcontroller is a system that inside it has CPU, ROM, RAM, I/O, Clock and other internal units that already connected and organized by the producer and packed in one chip, so that we need to program the content of RAM by following the rules of the fabric. Microcontroller is built from the same basic elements. Generally, in computer, microcontroller is a tool for doing the instruction that has given to it, so that the important part of a computerized system is the program itself by a programmer. This program is instructurized the computer to do complex tasks by the programmer [14]. Several features of a microcontroller are:

![Diagram Microcontroller ATmega328](image)

**Figure 4.** Diagram bloc microcontroller.

2.7. Sound sensor
Analogy of Sound Sensor is a simple module that function as an ear for Arduino project, so that it can activate actuator with particular sounds such as dialogue, knocking door, etc. This module can be used with Audio Analyzer for accepting input in a form of outside sound [15].

![Sound sensor](image)

**Figure 5.** Microcontroller ATmega 328.

2.8. Relay
In electronica world, relay has been known as the component that can implement switching logic. Before 70s, relay was the mastermind of controller circuit. After that, emerged PLC that replace the position of relay. The simplest relay was electro mechanic relay that gave mechanical movement when there was electrical energy (17,18). Simply put, electro mechanic relay can be described as:

- The tool uses electromagnetic waves for opening and closing the switch box.
- The switch box is moved mechanically by electrical energy.

This is a picture of relay that is sold in a market such as picture 7:
Figure 7. Relay is generally sold in the market.

3. System design

3.1. Analysis of data collection and system’s requirements
Diagam bloc is general picture of a system. In picture 8 is a picture of diagram bloc from educational system design that has been done in this research.

Figure 8. Diagram bloc system.

Overall, this system will be powered by LiPo battery where the function as energy saver and the output will be in the form of voltage and channeled to several components, such as Microcontroller, Sound Sensor and Relay.

Sound sensor functions as a sensor that detect and accept input in a form of voice command from the object that will be photographed, then the input will be sent to microcontroller. After the data has been proceed, then microcontroller will give an order to relay for taking the photo.

3.2. Overall schematic system
The overall schematic system consists of microcontroller, programmer, sound sensor, relay and led. Every block has different function. For a clearer image, it can be seen in Picture 9.

The part that has Microcontroller ATmega328 is connecting with DC voltage is function as 5 volts. Every port in digital pin 0 until 13 and pin analog 0 until 5 is bi-directional I/O with internal pull-up. In microcontroller block, there are three important parts, such as circuit of oscillator, circuit of and circuit of voltage.

The sound sensor is to accept the voice command. Then, the relay block is to connect camera shutter. In the end, the LED block as an indicator when the instrument is on.
Figure 9. Schematic system.

The following is a description of the system:

- The process will begin by doing initialization as a system, such as Sound Sensor module. Then, to make sure the condition Sound Sensor module has been connected to the system.
- If it is connected, then Sound Sensor module will turn on,
- If the Sound Sensor detected a sound with the speed sound more than 70Hz will directly proceed to the relay and it is connecting to the camera and the camera will take the shoot.
- If it is not detected a sound more than 70Hz, then it will be not proceeded by relay.

4. The implementation and the test

4.1. Testing the sound sensor

The test of Sound Sensor has been done to know if the sensor works or not and to know how sensitive is the sensor to the sound.

The first sensor is using a measurement of AVO meter on how much is the voltage when the instrument is on and detect a sound, such as in the picture 10 and picture 11.
Figure 10. Test of Voltage when the instrument is not On.

Figure 11. Test of Voltage when the instrument is On.

From the result of the test that has been done 3 times, it can be seen that Sound sensor has a voltage over 0v when it is not On, when it is On the voltage is 0v and when it accepts voice command the voltage is changed into 2.46v depends on the voice command that has been received. This is the result of the Sound sensor test that can be seen in table 1:

| No. | AVO meter | Voice Command                          |
|-----|-----------|----------------------------------------|
| 1.  | 0 v       | Before it is On                        |
| 2.  | 0 v       | When it is On and has not receive Voice Command |
| 3.  | 2.46 v    | When it receive Voice Command          |

A second test using a serial monitor shows the ADC value from the sound sensor reading.

Figure 12. Highest value of ADC readings.

\[
\text{Analog Voltage} = \text{ADC Reading} \times \frac{\text{System Voltage}}{1023}
\]

\[
\text{Analog Voltage} = \text{ADC} \times \frac{\text{Voltage}}{1023}
\]

\[
\text{Analog Voltage} = 504 \times \frac{5}{1023}
\]

\[
\text{Analog Voltage} = 2.46334311
\]
A third test to ensure that the value read is in accordance with the results of reading the AVO meter test and serial monitor using an oscilloscope.

![Figure 13](image1.png)

**Figure 13.** Testing has not detected sound.

The picture shows the oscilloscope value when the sensor has not detected the sound by giving a voltage value of 0 volts.

![Figure 14](image2.png)

**Figure 14.** Tests have been detected.

The picture shows the oscilloscope value of 2,463 volts from the sound sensor reading.

\[
\frac{\text{Resolution of the ADC}}{\text{System Voltage}} = \frac{\text{ADC Reading}}{\text{Analog Voltage Measured}}
\]

\[
\frac{1023}{5} = \frac{\text{ADC Reading}}{2.46334311}
\]

\[
\frac{1023}{5} \times 2.46334311 = \text{ADC Reading}
\]

\[
\text{ADC Reading} = 504
\]

4.2. Relay test

Relay test has been done to know how many volume of voltage. The test is done by a measurement of AVO meter on how many voltage is the sensor when it is on and detect a sound can be seen in Picture 15 and Picture 16:
Figure 15. Test of Voltage when the instrument is not On.

Figure 16. Voltage Test when the instrument is On.

From the result of the test that has been done for 2 times, it can be seen that Relay has a voltage over 0v when it is not On, when it is On the voltage is 4.8v. This is the result of the Sound sensor test that can be seen in table 2:

| No | AVO meter | Description          |
|----|-----------|----------------------|
| 1. | 0 v       | Before it is On      |
| 2. | 4.8 v     | When it is On        |

4.3. The overall test of the system

The overall test is done to test all of the components that are in the High speed photography automatically. The scenario of the first test is to place an instrument over ±50 cm that will work maximally and the scenario of the second test is the response of sound sensor when the balloon as an object will be destroyed in the photo.

The first scenario of the test is to put High speed photography automatic ±50 like in the picture 17:

Figure 17. Scenario to put automatic high speed photography.

The second scenario of sound sensor response when blow up the balloon in the photo, such as in the picture 18, picture 19, and picture 20:
Figure 18. Scenario blow up the balloon.

Figure 19. Scenario blow up the balloon with the remains of the balloon.

Figure 20. Scenario blow up the balloon with the remains of the balloon and water.

After it has been done 3 times with the measurement between instrument and object ±50 cm, there are several results that can be seen in table 3.

Table 3. The result of high speed photography.

| Object                              | Camera Setting          | Measurement | Result  |
|-------------------------------------|-------------------------|-------------|---------|
| Balloon                             | Shutter: 1/8000         | 50±         | Successful |
|                                     | Aperture: 7.1           |             |         |
|                                     | ISO: 640                |             |         |
| Balloon with the Balloon remains    | Shutter: 1/8000         | 50±         | Successful |
|                                     | Aperture: 7.1           |             |         |
|                                     | ISO: 640                |             |         |
| Balloon with the Balloon remains and Water | Shutter: 1/8000     | 50±         | Successful |
|                                     | Aperture: 7.1           |             |         |
|                                     | ISO: 640                |             |         |

From the overall test results, according to Komang Erawan as a photographer, he sees and compares the result of a manual picture and automatic High Speed Photography, stated that this instrument can take photos according to photographer’s interest.
5. Conclusion
From the test that had been done with automatic High Speed Photography, it can be concluded as follows:

- This tool can capture picture of a moving object that produce sounds automatically to make it easier in the work of photography.
- The voice sensor is placed in the upper of the instrument that can work optimal, where the sensor is functioned as detector when there is a blast sound from the object. This instrument is placed to the measurement of ±50cm from the object.
- In the middle of the process taking the picture with High Speed Photography, this instrument called dart has been used for blasting the object.
- The successful percentage and the response of High Speed Photography is increased than the manual, because in order to press the shutter manually the percentage of success when taking the shoot is increased 50%, and when using the High Speed Photography, the percentage of a success is increased until 100%.

References
[1] Roberts J 2009 Photography after the photograph: Event, archive, and the non-symbolic *Oxford Art Journal* 32(2) 281-298
[2] Ho R 2016 Enabling the Hardware for Computational Photography: Mark Horowitz Turned Ideas into Working Hardware Systems *IEEE Solid-State Circuits Magazine* 8(3) 52-56
[3] King J and Timacheff S 2015 Digital Photography for Dummies *Statewide Agricultural Land Use Baseline 2015*
[4] Bajac Q 2015 Contemporary Photography at MoMA *Photogr MoMA* 1960–Now
[5] Kopf J 2016 360° video stabilization *ACM Trans Graph*
[6] Stokman H 2014 The Future of Smart Photography *IEEE Multimed* 21(3) 66–71
[7] Wong C J, MatJafri M Z, Abdullah K, Lim H S and Low K L 2008 Development of Air Quality Monitoring Remote Sensor Using a Digital SLR Camera 2008 *IEEE Aerospace Conference* 1–6
[8] Wang Y, Liu Y, Heidrich W and Dai Q 2017 The Light Field Attachment: Turning a DSLR into a Light Field Camera Using a Low Budget Camera Ring *IEEE Trans Vis Comput Graph* 23(10) 2357–2364
[9] Wei W, Wu J, Gao G, Gu Z, Liu X, Zhu G and Wu G 2016 Study on pantograph arcing in a laboratory simulation system by high-speed photography *IEEE Transactions on plasma science* 44(10) 2438-2445
[10] Duanyang G, Yuebo D, Qingfeng Z and Dan L 2011 Study on the characteristics of gas jet for engine using high speed photography 2011 *International Conference on New Technology of Agricultural* 120-125
[11] Liu C, Chen C, Chung C, Lin P and Lin K 2009 Novel colored pulse lasers photography for high speed imaging 2009 *Conference on Lasers & Electro Optics & The Pacific Rim Conference on Lasers and Electro-Optics* 1–2
[12] Desnanjaya I G M N and Gandhika S I K D 2016 Rancang Bangun Alat Praktikum Mikrokontroler Di Stmik Stikom Indonesia S@CIES 7(1) 61–68
[13] Edwards J 2014 Signal Processing Leads a Photographic and Imaging Revolution [Special Reports] *IEEE Signal Process Mag* 31(3) 10–15
[14] Desnanjaya I G M N and Iswara I B A I 2018 Trainer Atmega32 Sebagai Media Pelatihan Mikrokontroler Dan Arduino *J Resist (Rekayasa Sist Komputer)* 1(1) 55–64
[15] Latif T, Whitmire E, Novak T and Bozkurt A 2016 Sound Localization Sensors for Search and Rescue Biobots *IEEE Sens J.* 16(10) 3444–3453