SyncBox - Synchronizer and Interface for High-Speed Macro Photography

Krzysztof Szklanny, Armand Stańczak, Paweł Wojtków, Sergio Cosentino, and Alicja Wieczorkowska

Polish-Japanese Institute of Information Technology, Koszykowa 86, 02-008 Warsaw, Poland
{kszklanny,armand.stanczak,pawel.wojtkow,sergio.consentino}@pjwstk.edu.pl, alicja@poljap.edu.pl

Abstract. The goal of this work was to create a fully automated synchronizer for macro photography, dedicated to water drop photography [2], [11]. An open-source electronics prototyping platform called Arduino was used for this purpose. The elaborated system includes a water system, a drop kit, and the synchronizer itself, attached to a digital photo camera. This system, named SyncBox, is simple, easy to use and fairly inexpensive. SyncBox can be operated using Dripper (the application interface) by a single mouse click, the pictures taken can be downloaded to a computer, and uploaded to the Internet. The proposed solution can be used as an interface for high-speed photography for water drop pictures, suitable for both amateur and professional purposes. The construction of the device, the interface, and exemplary pictures taken are shown in this paper. We conclude the paper with the proposed future works to make the entire system even more user friendly.

Keywords: Macro Photography, High-Speed Photography, Water Drop Photography.

1 Introduction

Phenomena that are too fast to see, if photographed, give very interesting results, admired in arts, and often used in advertising. Water drop photography is one of examples of events that could not be seen at all without a camera. High speed photography allows capturing such fast and amazing phenomena. There exist tools for high speed photography and, in particular, dedicated tools to photograph droplets of water, or milk, or other liquids. Tools available on the market include the photography trigger Camera Axe [5], the high-speed photography controller StopShot [7], and the SplashArt kit [8], However, such tools cost a few hundred dollars and are expensive for amateurs. CameraAxe, which is the least expensive and best solution for amateurs, allows connecting a camera, flash lamps, and sensors. However, even such a simple device is not so easy to use, as it's software requires adjustment of various values and settings, which can be difficult to a user. Therefore, we decided to build a system at a fraction of this

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cost, to make water drop photography available to anyone interested in capturing water splashes, without investing into a professional studio. This solution can also be used by professional photographers.

The system presented in this paper is named SyncBox. It is a synchronizer for high speed macro photography, which can work with virtually any digital camera available in the market, provided the appropriate cable is used to connect the camera with SyncBox. This solution is based on Arduino [1], [3], [4], [9], [10], an open-source electronic prototyping platform, which can be connected to a computer with Windows, Mac OS X or Linux system, and it costs only about 20 Euros. It allows control over electric signals. The device build in the described work is a synchronizer, taking a picture when a water drop hits water surface, series of pictures can also be taken. The complete system also includes a water container, piping, a valve for releasing drops, a water pump, and altogether it costs about 50 Euros. The settings of the elaborated software allow choosing the desired effect in the picture. The details of the system are given in Section 2, and the interface is described in Section 3. Exemplary pictures taken using SyncBox are shown in Section 4. The paper is summarized and concluded in Section 5.

2 Construction of SyncBox

The SyncBox synchronizer for high-speed macro photography is based on Arduino Uno microcontroller [1], see Figure 1. The Arduino board was connected to a personal computer with Windows operating system. Utmost care was taken to assure repetitiveness of the resulting photographs, and full control over the pictures taken. Control with LCD Shield, manipulated with joystick, was also considered in the planning phase, but it would require making this project in Nokia environment and changing the entire architecture. Therefore, this solution was discarded.

Our synchronizer (Figure 2) consists of three removable parts that are removable for easy access, upgrade and repair. It consists of:

- central processing unit (CPU), powered from Arduino without the need for external power source;
- relay unit, created from scratch for the SyncBox system, to control AC 230V operated devices; and
- power adapter unit, to provide up to 4 water valves with DC 12V power.

The controller triggers electric impulses of the desired pulse length and frequency, at the precisely defined instant. Initially, a laser system consisting of a laser emitter and a photoresistor was used for triggering impulses sent to the peripheral devices. However, it required precise positioning of the emitter and the photoresistor, dark working conditions and it introduced delay to the entire macro-photography system. Therefore, the laser system was discarded.

The Arduino board has analog and digital inputs and outputs, and it is connected to the host computer via USB connector. The computer was applied for programming integrated circuits. Although Arduino cannot handle multithread

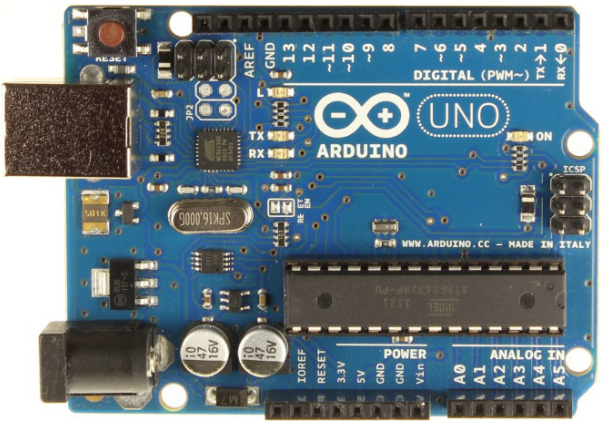

Fig. 1. Arduino Uno R3 board, front view [6]

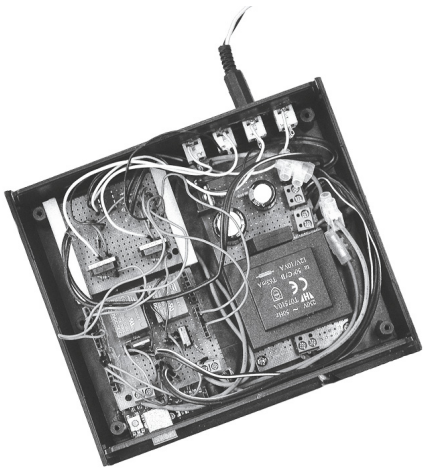

Fig. 2. The SyncBox synchronizer box

Fig. 3. The SyncBox main equipment. Devices shown on the shelf, the synchronizer box (black) and the pump (gray, partly behind framing) are normally placed aside, as a water container is placed here instead. In the middle part of the framing, the valve can be seen.

tasks, it can control potentially unlimited number of devices, since basic digital outputs can be extended using simple integrated circuits.

The synchronizer can be connected to any digital camera; the main equipment is shown in Figure 3. The camera is then connected to the system (placed on a tripod), and two flashes can be attached to this system. Fast flashes were used when taking photographs presented in this paper; when set to 1/320 s and 1/64 flash power, clear and sharp pictures were obtained.

The drop kit consists of a rectangular 1 liter water container, piping mounted on aluminum framing, a water pump to maintain pressure in rubber ducts, and a solenoid valve. The position of the camera is important, since it must be close enough to water in order to get high quality picture, but if it is really close, it should be protected from water drops.

2.1 Controlling Water Drops

The heart of the system is Dripper - the application for steering the synchronizer. This software allows changing the parameter settings. The user can control the size and number of drops, which allows creating desired shapes (see Section 3). On the mouse click, the drop is released, and the picture is taken when the drop contacts the water surface. The time of this contact was found on the basis of

the 1000 FPS movie taken with Casio Exilim EX-Z200 camera, which allowed finding the contact time with 1-ms precision.

The following parameters of water drops can be controlled:

- 1st drop size: represented as the time [ms] of 1st opening of the valve;
- 2nd drop size: the time of 2nd opening of the valve, in [ms];
- time interval, in [ms], between the first and the second drop release;
- time delay, in [ms], after which the camera takes the picture.

The electrical impulse is sent from CPU to the relay unit, which first triggers the water pump, and then sends impulses, passing through SyncBox main board to the solenoid valve and to the camera. Time delay parameter controls the time between these impulses. After the drop is released by the valve, the impulse is switched off; the switch off time is controlled by the drop size parameters. After the picture is taken and saved, CPU switches off all impulses and waits for next commands.

The solenoid valve we applied, Magnum 12V DC, is the main device producing water drops. Opening and closing time of the valve is controlled, and since the drops are automatically released, drops of the desired and constant size are obtained. Minimum reaction time of our valve is 13 ms. Although this solenoid is a gas valve, it works well with water in our drop system.

The last stage of the system design was to test the quality and performance of SyncBox. The system successfully handled over 3.000 individual photographs in our tests.

3 Interface of the SyncBox

The existing solutions are usually based on Java technology. On the contrary, our interface is based on HTML5 and jQuerry. This solution allows designing user-oriented, ergonomic interface. Most of the existing solutions require additional steps to run the application, and setting appropriate configuration of at each run of the device. This usually is not easy for a user.

The graphical interface of SyncBox, i.e. Dripper, was designed using HTML5 and CSS3. This allowed dynamic change of settings without additional configuration of Arduino or restarting the system. This functionality was achieved through separating the interface from the main program code. Settings changes, if needed, are simple and intuitive to do by the user. The interface is user friendly, works well, and was easy to implement. The graphical user interface of our application is shown in Figure 4. The interface was implemented in Polish, with the following options:

- LISTA KONFIGURACJI - list of configurations,
- USTAWIENIA DODATKOWE - additional settings,
- URUCHOM POMPKE - run water pump,
- ZDJECIE JEDNEJ KROPLI - 1 drop photo,
- ZDJECIE DWOCH KROPLI - 2 drops photo,

– ROZMIAR KROPLI - 1st drop size,
– ROZMIAR DRUGIEJ KROPLI - 2nd drop size,
– OPOZNIENIE APARATU - time delay.

The list of configurations allows adding and editing of predefined settings (profiles) which can be used while working with SyncBox. Additional settings allow running the device in a loop, i.e. repeating drops, for 1-drop or 2-drop setting. Running the water pump might be needed in the case of the pressure decrease.

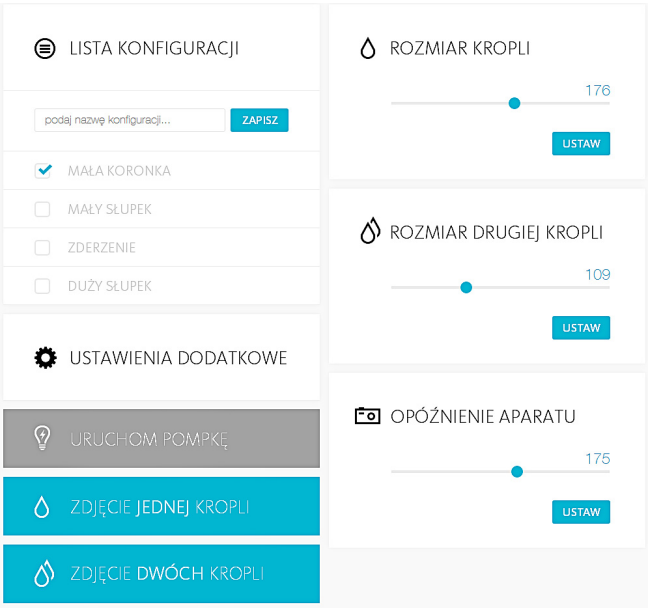

Fig. 4. Dripper - graphical user interface of our application. The interface was prepared in Polish. Available settings: LISTA KONFIGURACJI - list of configurations, USTAWIENIA DODATKOWE - additional settings, URUCHOM POMPKE - run water pump, ZDJECIE JEDNEJ KROPLI - 1 drop photo, ZDJECIE DWOCH KROPLI - 2 drops photo, ROZMIAR KROPLI - 1st drop size, ROZMIAR DRUGIEJ KROPLI - 2nd drop size, OPOZNIENIE APARATU - time delay.

Before the system is used, Arduino must be connected to the computer (and to the application). This is done by a single click on the button, see Figure 5.

4 Taking Pictures with SyncBox

Three basic water drop shapes can be photographed using SyncBox:

1. Shape 1, resembling a column, see Figure 6;
2. Shape 2, resembling an umbrella, see Figure 7;
3. Shape 3, resembling a crown, see Figure 8.

Fig. 5. The screenshot of the interface for connecting Arduino with SyncBox; PODLACZ SYNBOXA - connect SyncBox. The user can start using the system by clicking one button, POLACZ (connect).

The shapes are controlled by means of parameters presented in Section 2.1. During works on the described system, the obtained photographs were also placed in an Internet gallery, see Figure 9. No sophisticated equipment is needed to taking such pictures. The presented photographs were taken using inexpensive digital cameras, like Canon 400D, Canon 450D and Nikon D5100, and second hand 10-Euro lenses.

In further works, we would like to prepare a new gallery, with a selection of best pictures available to show the capabilities of the SyncBox system.

5 Summary and Future Works

The goal of the presented work was to create the system for high-speed macro photography, dedicated to water drop pictures, and to make the system as simple as possible. The system is inexpensive, and can be extended according to users' needs. It can be utilized by both amateurs and professional studios.

The elaborated system, called SyncBox, is based on Arduino board and open-source environment, which can be used with all commonly used computer systems. SyncBox can be operated by a single mouse click. The elaborated interface, called Dripper, is simple and easy to use.

The quality of the work depends on cameras and lenses used, but inexpensive ones can also be successfully applied. The presented photos were taken in most cases using inexpensive digital cameras, and second hand 10-Euro lenses.

Fig. 6. Water drop, shape 1, resembling a column; picture taken using SyncBox

Fig. 7. Water drop, shape 2, resembling an umbrella; picture taken using SyncBox

Fig. 8. Water drop, shape 3, resembling a crown; picture taken using SyncBox

Fig. 9. Pictures taken using SyncBox, shown in the Internet gallery

Further works are planned on SyncBox. First of all, we would like to minimize the entire system, in order to make it easily portable. Additionally, we would like to obtain multi-color shapes, by adding another solenoid valve (or valves), to draw colored water from another container (or containers). The next step will be to make the project wireless, with peripherals controlled over the Internet, thus making it available worldwide.

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References

1. Arduino, `http://www.arduino.cc/`
2. Gorham, D.A., Field, J.E.: High-Speed Photography of Liquid Jets. In: Rolls, P.J. (ed.) High Speed Photography, pp. 442–447. Springer US (1975)
3. Kelly, J.F., Timmis, H.: Arduino Adventures. Escape from Gemini Station (2013) ISBN: 978-1-4302-4606-0 (Online)
4. McRoberts, M.: Beginning Arduino (2013) ISBN: 978-1-4302-5017-3 (Online)
5. CameraAxe, `http://www.cameraaxe.com/`
6. Chalkley, A.: The Absolute Beginner's Guide to Arduino, `http://forefront.io/a/beginners-guide-to-arduino`
7. Cognisys Inc.: StopShot - High Speed Photography Controller, `http://www.cognisys-inc.com/stopshot/stopshot.php`
8. High Speed Photography UK: SplashArt and Phototrigger products and demos, `http://www.phototrigger.co.uk/`
9. Oxer, J., Blemings, H.: Practical Arduino. Cool Projects for Open Source Hardware (2010) ISBN: 978-1-4302-2477-8 (Print) 978-1-4302-2478-5 (Online)
10. Shaikh, M.H.: Study of Arduino for Creative and Interactive Artwork Installations. In: Chowdhry, B.S., Shaikh, F.K., Hussain, D.M.A., Uqaili, M.A. (eds.) IMTIC 2012. CCIS, vol. 281, pp. 478–488. Springer, Heidelberg (2012)
11. Sakharov, A.A.: On New Elaborations in International Terminology of High-Speed Photography and Cinematography. In: Rolls, P.J. (ed.) High Speed Photography, pp. 592–593. Springer US (1975)