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# Prototype of sun projector device

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**Abstract.** One way to introduce astronomy to public, including students, can be handled by solar observation. The widely held device for this purpose is coelostat and heliostat. Besides using filter attached to a device such as telescope, it is safest to use indirect way for observing the Sun. The main principle of the indirect way is deflecting the sun light and projecting image of the sun on a screen. We design and build a simple and low-cost astronomical device, serving as a supplement to increase public service, especially for solar observation. Without using any digital and intricate supporting equipment, people can watch and relish image of the Sun in comfortable condition, i.e. in a sheltered or shady place. Here we describe a design and features of our prototype of the device, which still, of course, has some limitations. In the future, this prototype can be improved for more efficient and useful applications.

## 1. Introduction

Describing the Sun is one among various ways to give introduction and education on astronomy to public, including students. Before doing that and the related activities, we should know properly some hazards of direct viewing the Sun. Some points are needed to take care of, e.g. not to use unfiltered optical device when viewing the Sun directly. In general, there are at least two safe view methods. First, using aperture filters attached to the device to reduce intense solar radiation; and second, the technique of projection. The second method belongs to indirect way, so that it is still the safest of all the ways in observing the Sun [1]. We do not have to worry about the filter coming off the telescope.

There are many devices that has been built for indirectly observing the Sun. Some classic and popular devices are known as coelostat and heliostat, which are manifestation of the remarkable ideas of the projection's techniques. In those devices some mirrors and lenses are used [2], incorporated with particular gears to locate and track smoothly the daily motion of the Sun.

By improving the scheme of light deflection and image projection, there are a number of advantages when describing the Sun to a group of people. The screen can be placed in a sheltered area or indoor, so that people simultaneously can watch the sun image in a shady place without basking under the sun. If needed, not only device related descriptions can be explained by a tutor, some folks and astronomy related stories can also be comprised additionally in a suitable place.

Here we describe our prototype of such a device of sun projector. The device is a compact and light, easy to transport and set up, uses minimum optical elements and self-power-supplied solar-tracking. The device is designed to be reproducible using low-cost and easily get hold of materials.



However, the device prototype has some limitations that are subjects for better improvements in the future. The benefits of development of this device can be widely understood.

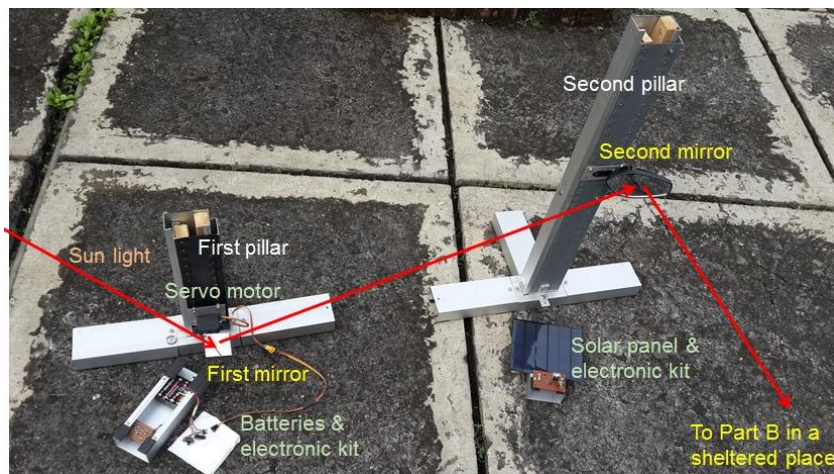
## 2. Prototype design

Before designing the device some aspects of its capabilities are considered. Capabilities of the device include: constructing clear image of the sun disk in a sheltered place, tracking daily motion of the Sun, not requiring electricity network, being easily set up, being compact, light and high portability, being low-cost and simply reproducible.

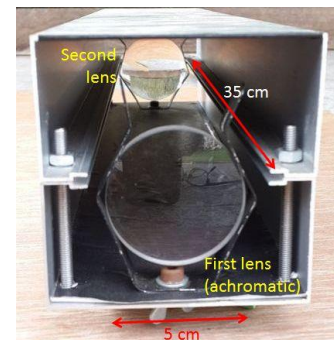
Based on its functionality, the device has three schemes, comprising optical, electronic (with motor), and mounting systems. On the other hand, in order to construct image in a sheltered place, we separate the device into two parts, i.e. Part A that is located outside, basking under the Sun, and Part B which is located in a sheltered place or indoor. Tracking motion of the Sun and deflecting its light are main purposes of Part A, and then projection of the sun disk image seen on the screen is a role of Part B.

### 2.1. Optical system

Diameter of sun image on screen is an important consideration. Although in general, sun image can be projected in any size, but the light intensity decreases very rapidly with increasing scale of the projection [3]. A sun image diameter of 15 cm on screen is adequate [1,3], so that lens magnification and the distance to the screen should be examined.



**Figure 1.** Part A includes optical (mirror), electronic (and motor), and mounting systems.



**Figure 2.** Part B for sun disk projection on screen

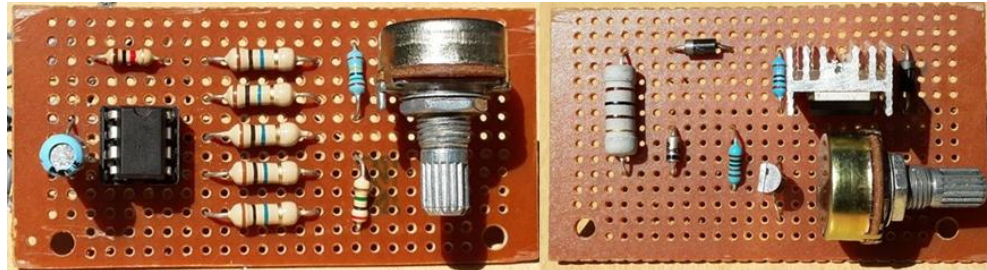
Basic concepts of optics, such as principles of mirror reflection and lens refraction, are available in references, e.g. [2]. After surveying materials available in the market, we set that optical system consists of two flat mirrors in Part A (figure 1) and two convex lenses in Part B (figure 2). A servo motor is attached on the first mirror in Part A in order to track motion of the Sun. The second mirror is fixed, but manually adjustable, to deflect the sun light coming from the first mirror to Part B located in a sheltered place (see figure 1). Part B has mainly an optical system (figure 2), comprising a configuration of an achromatic lens (first lens with focal length 30 cm) and a lens (second lens with focal length 5 cm). The second lens can be taken off if necessary.

### 2.2. Electronic system

A set of four rechargeable batteries (type: AA) are arranged as power supply (figure 1) for the servo motor. The motor is mounted on the first pillar of Part A with adjustable elevation for tracking motion of the Sun. An electronic (timer) kit/circuit is developed for this purpose (figure 3). In line with this, a solar panel (9 volt) with a corresponding electronic kit (figure 1) are also developed for the purpose of



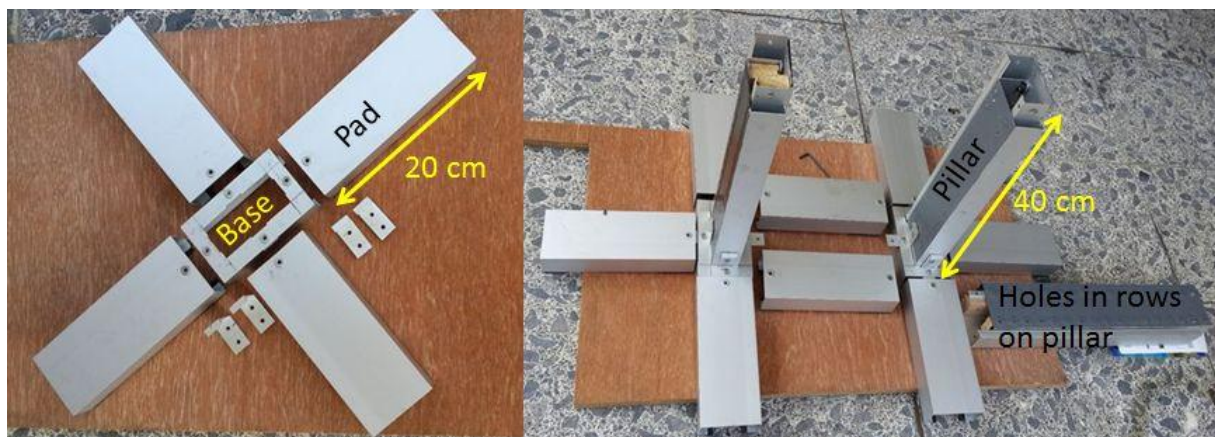
charging the other set of batteries (figure 3). The two sets of batteries can be mutually changeable when one set of them is low in power. The electronic kits are equipped by switches and put underneath the pads (figure 1).



**Figure 3.** Electronic circuits for controlling speed of the servo motor (left) and recharging a set of batteries using solar panel (right). Length of a kit board is 7 cm.

### 2.3. Mounting system

Mounting system is a dominant component for Part A. It is made of aluminum because of its light, strong, and low-cost. The system consists of two separate mountings (group of base-pads-pillars, figure 4), but if needed, a pad can be mutually used by both mountings. Pillars are developed in segmentations for easy arrangement in packing. A segment of pillar can be augmented with other segment when installing motor or mirror at higher elevation.



**Figure 4.** Left: A base for supporting and foundation of pillar, and pads for maintaining stability and its underneath for storage of the electronic kits. Right: Pillar has holes in rows for adjusting elevation of the attached motor and the deflection mirror. The pillar segment can be augmented with other segment if necessary.

## 3. Discussion

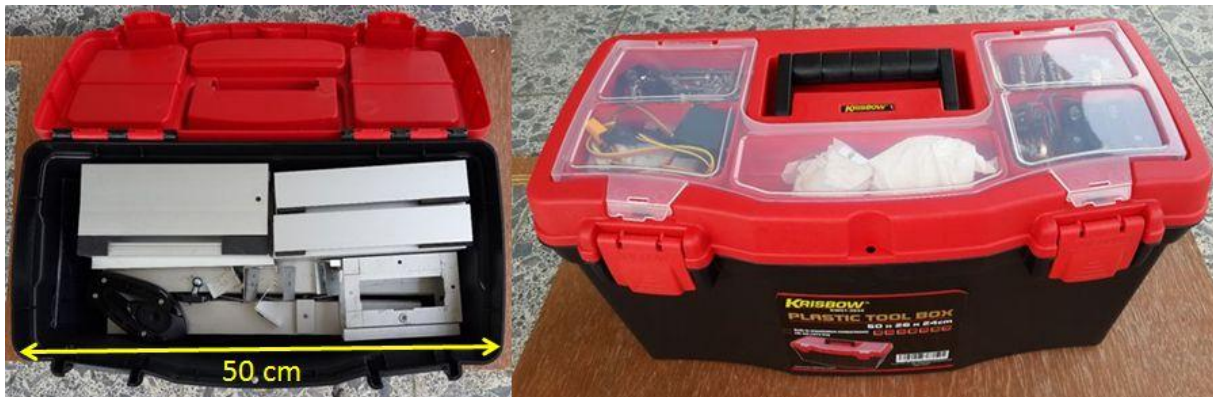
We have performed many experiments related to optical, electronic, and mounting systems. Optics provided in the market are rather limited but some are usable. We use ordinary mirrors in Part A since it is rather difficult and expensive to get high quality mirror. However, we use fine lenses in Part B, and eventually, the sun image can be suitably projected on screen although it is not very sharp. We believe that the precision and alignment of the optical system contributes essentially to quality of the image.

Because of lack of software programming capability, we finally chose a servo motor instead of using stepper motor. Motion of the servo motor has a time-lag, not smoothly as that of programmable stepper motor. We have set an electronic timer circuit so that the constructed image stays on the screen. Using

stepper motor is better for smoothly tracking the sun motion in the sky. This will be one subject among the future improvements.

Our surveys reveal that aluminum is the well-chosen material for developing the mounting system. By two people, it takes about 30 minutes to set up the device. We have tested also the stability of a mounting exposing it to strong wind from a fan having high speed propeller, and it works well.

For reason of portability and easy to transport, we use a tool box (figure 5) that can store the entire components of the device. Total weight is less than four kilograms. Fortunately, the bottom of the box inside can also be used as a screen since it is covered completely by the box's sides. The sun disk image can be seen satisfactorily.



**Figure 5.** A box for packing the whole components of the sun projector device.

The device is also provided with appropriate instructions, which are simple and contain decent lesson plans. For the whole components of the device, we spent less than one million rupiah, including a box for packaging system. We believe that our device belongs to low-cost instrument and it can also be reproduced easily.

#### 4. Summary

A prototype of sun projector device has been developed. People can watch the sun disk in more comfortable way in a sheltered place. The device is portable and self-support (solar panel) power supply using rechargeable batteries. With this support, it is capable to track the daily motion of the Sun. In the future the prototype needs more improvements.

#### Acknowledgments

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