Optimizing solar panel output by using light sensors, driving motors and fuzzy controller

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Abstract. Indonesia has limited electricity supplies and often experience blackout. On the other hand, this country is rich with sunlight. Sunlight is always available for the entire year due to the tropical weather and earth position is near to Equator. However, solar cell usage is still limited to be applied. This paper presents solar panel controller design to maximize the power output by using light sensors, two driving motors and fuzzy logic controller. The prototype is modelled and simulated based on measured data. Simulations have been made between the designed systems versus static system. The recorded data shows that by controlling solar panel following the position of the sun, the power output increases about 15.69 % over the static system.

1. Introduction
Solar cell is the semiconductor component converting solar energy to electric current. This cell has been used widely to generate the alternative energy source both for small and large scales. Solar cell or photovoltaic cell is basically a semiconductor diode that devised to produce 0.5 to 1.0 volt per cell with current flow depending on the light intensity. The solar power from the sun reaching the earth surface may reach 4.8 kWh/m²/day [1]. However, as the solar cell efficiency is limited, it can only generate up to 25% according to the new solar cell achievement [2]. Therefore, in order to maximize energy conversion, the cell surface should receive as maximum as possible of sunlight exposure.

The power magnitude depends on the intensity of received sunlight. Weather at this point and shading influence the system the most. Fog and cloud easily degrade power level as light intensity decreases. Besides, designing cell surface that is able to trap as optimum as possible the incoming rays, the other rational solution is to expose cell surface as optimum as possible. Many works have been performed to ensure maximum sunlight is on track. Some techniques are proposed by using intelligent systems [3-6]. The dual axis controller is the most used method on how motor moves the panel [7]. This paper studies solar cell implementation in Medan, Indonesia by recording the potential energy resulted from the sun in this area. Sunlight intensity is surveyed, system is modelled, and the automatic tracking is simulated to measure how optimum the system can be. None of the novel system is proposed; however, as sunlight position is mostly in southern or northern hemisphere, the works are researching the impact of sunlight tracking to energy generations in this area. In order to do so, two motor controls are employed. The first one is to follow solar movement from east to west, other motor to adjust north and south solar position. The controller employs the simple fuzzy neural network. The works combine real measurement and simulated evaluation. The following sections outline the research methodology and the outcomes.
2. Methodology

In order to assess the performance of solar panel after the improvement had been optimized by sensors, actuators and controller, system is modelled as in figure 1. To obtain the maximum position, four LDR sensors are located in east, west, north-south directions. Sensors outputs are fed to fuzzy controller to decide how two motors are actuated. The two motors are employed to move solar panel either to east-west or north-south directions.

Sensor responses are important to determine the maximum solar radiation intensities. The higher the radiation, the lower the LDR resistance. Figure 2 shows the LDR responses to sunlight for both east-west and north-south sensors. This data is fed to simulations to determine the right position of solar panel. However, the information should go to fuzzy controller first before moving the actuators. This can be shown in figure 2 below;
Fuzzy rulers are set to obtain whether sunlight intensity is bright or dark. This requires sets of rules such as bright is when resistance is 0-320 Ohm, slightly bright if it is 300-800 Ohm, dimmed if 500-1400 Ohm. For dark if 1000-1600 Ohm. Meanwhile, the motor driver is set as minimum rotation or maximum rotation, the rules are set for instance a minimum if the position from 100-650, close if position is from 600-1200, far if position from 1000-1500 and maximum if position larger than 1400. The fuzzy output is obtained to actuate both motors. For instance, if east sensor in bright, the west sensor is dimmed, north sensor is bright and south sensor is dimmed, motor is then set to close.

The whole processes are implemented by using programming script depending the microcontroller type employed in system. Figure 3 shows the software flow to implement the system. Every time panel moves, the new position is searched and the new output is compared to the maximum result. In order to avoid oscillated system, fuzzy rules are adjusted accordingly. This paper employs MATLAB Software to evaluate and simulate the system. It can visualise in figure 3.

Figure 2. Sensor responses
3. Result and Discussion
The dynamic positioning of solar panel is proven to increase the open circuit output voltages for all hours. Figure 4 shows the results. The maximum voltages are obtained from about 0900 am to 1500 am. The dynamic solar panel is consistently increasing the output voltages. Although the dynamic system results some unstable output, this will not be an issue as stabilizer is easily implemented.

Figure 3. Controller software flow
The increasing voltage is oscillated a little bit when solar panel connected to the load. However, the level is maintained to the level of the static system generated. Figure 5a and 5b show the voltage and current characteristics when system is loaded.
In average, loaded voltage is boosted about 4.9% and current flow jumps to more than 10.0% higher. This results in an increase in the average output wattage about 0.5 watt. The output power is shown in figure 6.

**Figure 5.** Loaded output comparisons

**Figure 6.** Output power comparisons
4. Conclusion
This paper has examined the output optimisation of solar panel by using two set of sensors: East-west and north-south where their outputs are fed to fuzzy controller to determine how east-west and north-south motors are actuated. System is evaluated through data recording and system simulation. The results show that the dynamic solar panel outperforms the static system, increasing open load voltage by 3.99 % from 17.93 Volt in the static system to 18.64 Volt in dynamic system. The loaded voltage and current of dynamic system are also better producing power improvement of 15.69 % in average.

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