

## **Using Smartphone Sensors for Insolation Detection**

Smartphones are equipped with devices that can be used in detecting optimal orientation for solar energy. The most relevant device is the light sensor, which detects light to adjust screen brightness. Another device in the smartphone is the Inertial Measurement Unit (IMU) which detects acceleration, magnetic field and orientation of an object. IMU is used to support GPS, and can be used, in conjunction with the GPS location data and sun's traversal path, to calculate the optimal orientation for insolation.

### **State-of-the-art**

Internet Enabled Solar Tracker, a product published on instructables.com by the user MidnightMaker, is a solar panel that can be controlled by a phone application using sun's traversal data from the internet and adjusting the solar panel by measurements from an accelerometer and a magnetometer [1]. This product uses a solar tracking algorithm online to find the optimal azimuth and elevation angle, and adjusts its stepper motors so that the solar panel is receiving the maximum amount of solar energy. The approximate cost to produce the tracker is \$250.

Samsung Galaxy S5 and newer models have an adapt display option where an ambient light sensor on the phone can detect white, red, green and blue light independently to select the best color range, sharpness and saturation for its display [2]. Adapt display enhances screen view by adjusting color parameters when the lighting conditions in the surrounding environment change. The average cost of a Samsung Galaxy S5 is \$200.

### **Underlying Technologies**

An important part of the Internet Enabled Solar Tracker is the algorithm to find the azimuth and zenith angle of the sun for specific time and location. The azimuth angle is the horizontal angle of the sun's location relative to north. The zenith angle is the angle between the normal vector of the object and the sun. The C++ code implementing the algorithm takes in parameters such as date, time, longitude and calculates ecliptic (origin is Sun or Earth) and celestial (origin is Earth) coordinates. Local coordinates are found using ecliptic and celestial coordinates and these yield the azimuth and zenith angles. Trigonometry is used in most of the steps [3]. These angles are the preferred orientation of the solar tracker. To adjust the orientation given these two parameters, an LSM303 breakout board was used. This board acts like a tilt compensated compass, which can accurately measure heading even if the object is tilted. The tilt is found by accelerometer readings and the heading is calculated by magnetometer data [4].

Adapt display option has an ambient light detector component which is an analog circuit that scales received light and represents it as a voltage factor so that the application can adjust lighting

depending on the quality of the incident light. A patent on ambient light sensor describes the device stages as a current amplifier circuit that receives light and a changeover control circuit that responds to the change in the amplified current so that light fluctuation is detected [5]. The ambient light sensor in Samsung Galaxy S5 can monitor changes in white, red, green and blue light. For instance, in an outdoor environment where white ambient light is abundant, adapt display will increase brightness to prevent glare. If a room uses blue neon lighting, adapt display will increase the brightness of red and green pixels so that the screen display can compensate for the color balance [2].

### **Building Blocks**

Internet Enabled Solar Tracker requires hardware and software components. Hardware is composed of wooden gears and stepper motor drives for orientation, and electronic circuitry for control and calculating acceleration and magnetism. The software of the solar tracker uses two algorithms: one to find the sun's azimuth and zenith angles, the second deriving tilt and heading to match the two angles. SQL Server software is used to receive angle updates from the algorithm per date and time. JQUERY Mobile software is used to code a mobile application that enables a smartphone to interface with the solar tracker [1].

Adapt display's hardware component is the ambient light sensor located on the top of Samsung Galaxy S5's screen. The sensor is the main input for the smartphone's display settings. Adapt display is an option under display preferences, it enables automatic adjustment to the screen settings [6]. Adapt display is an embedded system, comprised of the ambient light sensor and the Android display software.

## References

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