Improving the Response, Accuracy and Efficiency of Solar Tracking Systems Utilising Hybrid Sensing

A Brief History of Solar Tracking

Solar trackers are designed to improve the amount of solar power that can be generated from solar panels. The longer a solar panel is facing the sun directly, the more energy that can be generated. This is achieved using sensors and motors to position solar panels to face the sun. An improvement of 50% solar power generation can be achieved using a tracker compared to a stationary panel. Trackers can therefore improve the amount of electricity generation, and provide more energy without requiring more solar panels.

Types of Tracking

There are two main types of trackers, single and dual axis trackers. A dual axis tracker can track the sun vertically and horizontally, whereas a single tracker can only track in one of those directions.
Dual axis trackers are the best option to track the sun as they provide increased output power generation as they can more accurately face the sun for longer.

Types of Sensors

Typically, light dependant resistors (LDRs) are used to track the sun as they are cheap and sensitive to light. But, LDR's are susceptible other light sources which can affect tracking performance and only work under ideal conditions. A better option is the phototransistor which has improved accuracy and a quicker response to changing light. UV sensors are even better; they're the most accurate and can track the sun even during light to moderate cloud Cover as they can detect the UV rays that penetrate clouds. The main problem with the UV sensor is the accuracy comes at the cost of a slower response time; they are slow to react to changing lighting conditions.

Proposed Hybrid Sensing System

The hybrid sensing system proposed utilises the fast response of the phototransistors and the accuracy of the UV sensors to create a tracker which is both responsive and accurate. The phototransistors will first find an approximate location of the sun, once complete, the UV sensors will take control and improve the accuracy of tracking. This may be beneficial for use on vehicles; vehicles move rapidly relative to the position of the sun and so the hybrid sensing could allow the solar panel to react to the vehicle movement quickly and accurately.

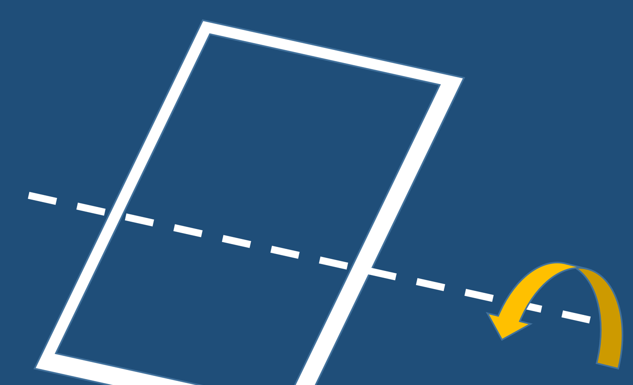


Fig. 1
Single-axis Tracker (Elevation)

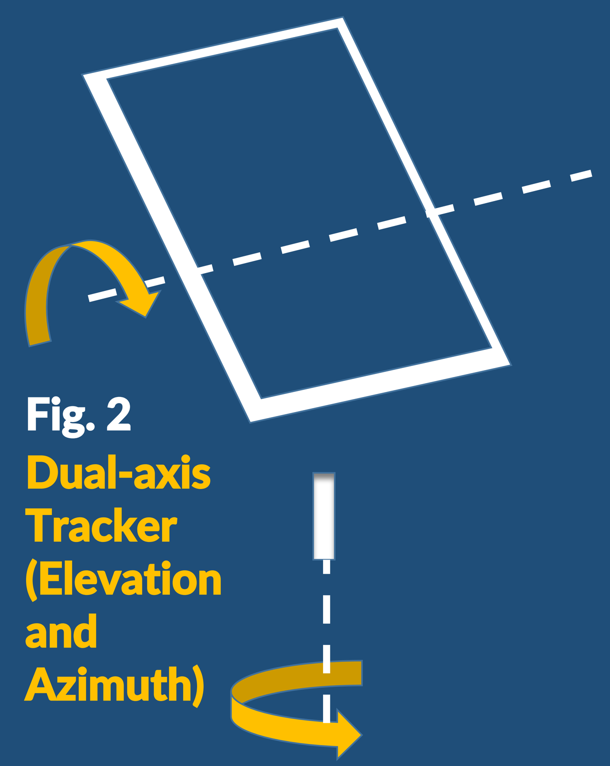


Fig. 2
Dual-axis Tracker (Elevation and Azimuth)

How Hybrid Tracking Works

See figure 3:

1. Phototransistors are first used, and their output values are read by a microcontroller. The values are compared to determine the light direction.
2. If the sensor values are equal, an approximate location has been found and the UV sensors take control of tracking. If not, the tracker moves in the direction required and the loop starts again.
3. If phototransistors are equal the UV sensor values are read,
4. and the light direction is determined.
   The UV sensors are used at this point to increase the accuracy of tracking.
4. If the UV sensors are all reading the same light intensity, the sun has been accurately found and no actuation is required.
   The sensors are continuously read to ensure no movement has occurred.
5. If the UV output values are not equal, the tracker moves in the required direction, and the loop starts from the beginning. This is to ensure the phototransistors check for any sudden light direction changes.

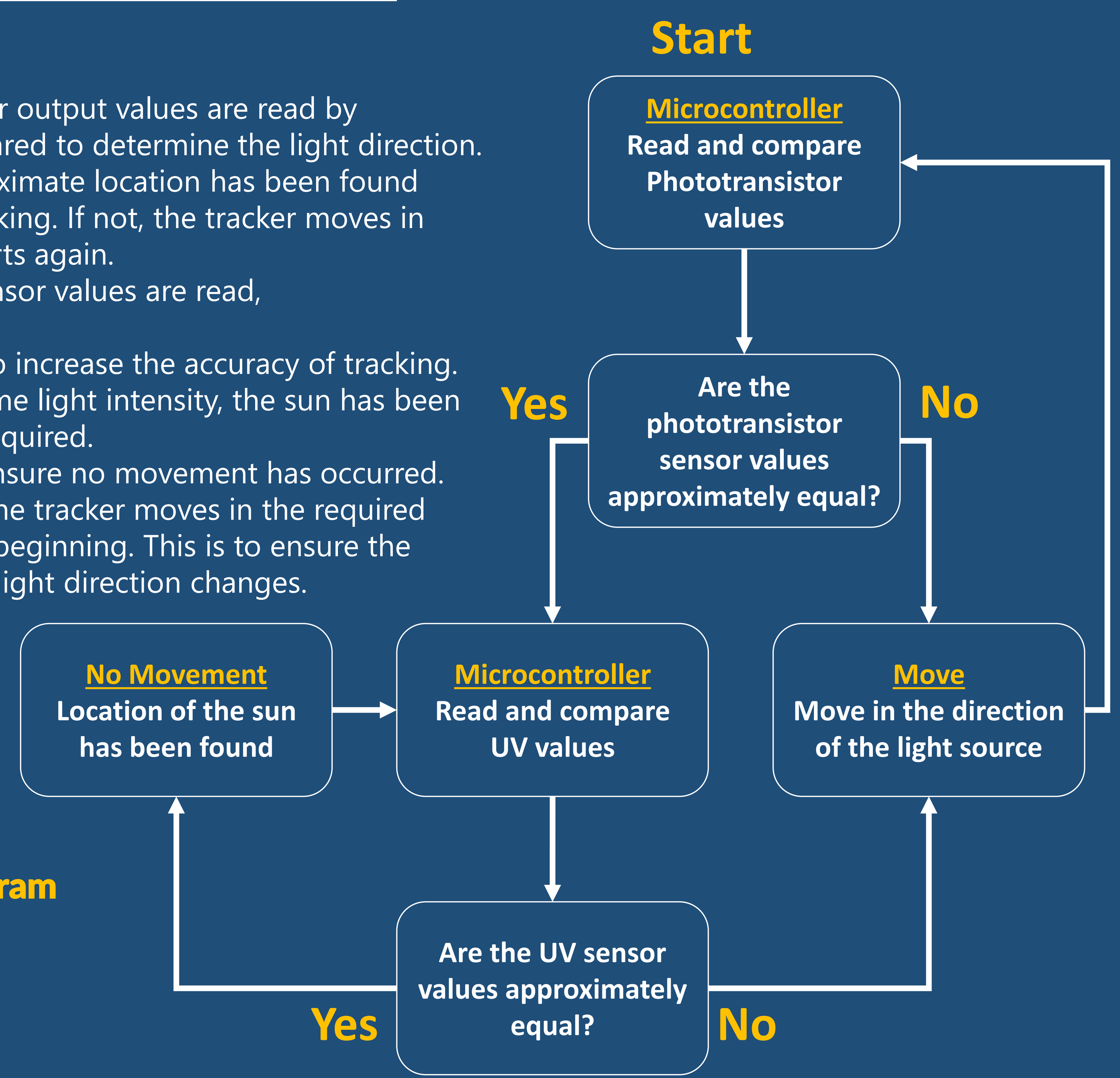


Fig. 3
Hybrid sensing flow diagram

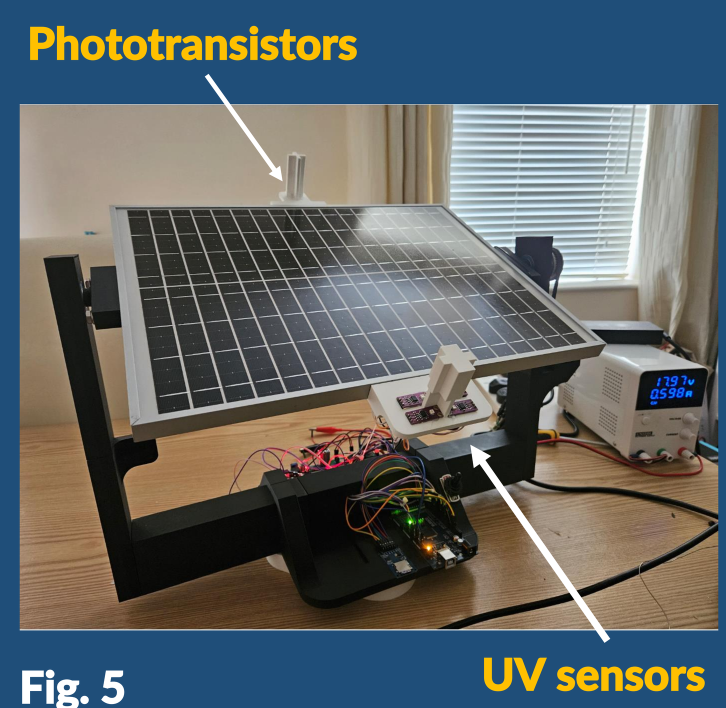
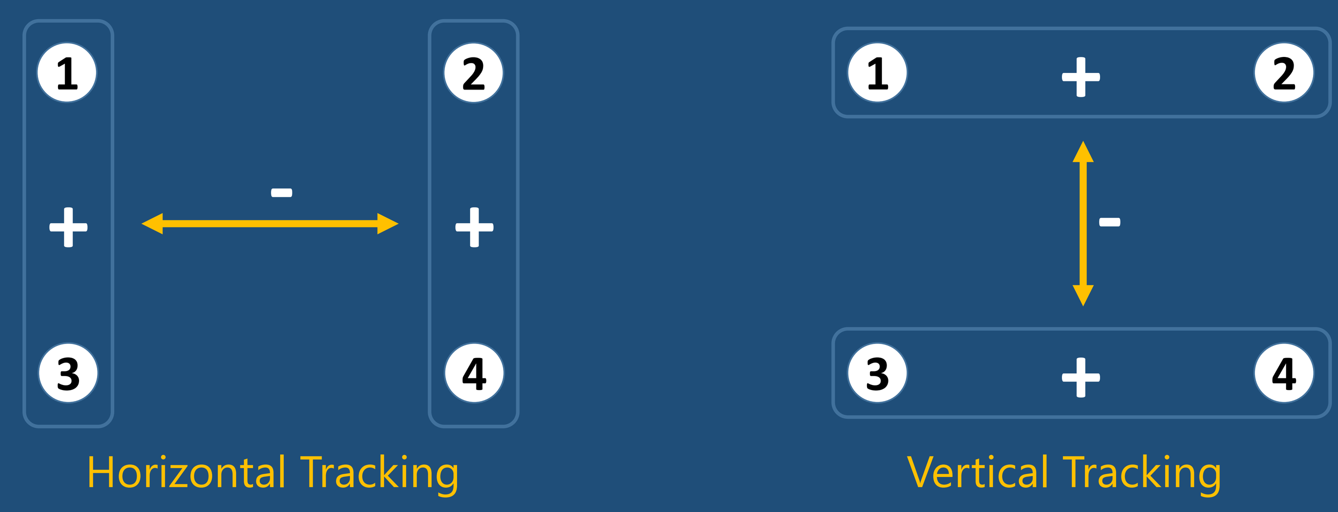


Fig. 5
Dual-axis hybrid tracker

How to Track Light

Four sensors are arranged as seen below, numbered 1 to 4. The sensor values are compared to find the position of the sun vertically and horizontally, see figure 4:



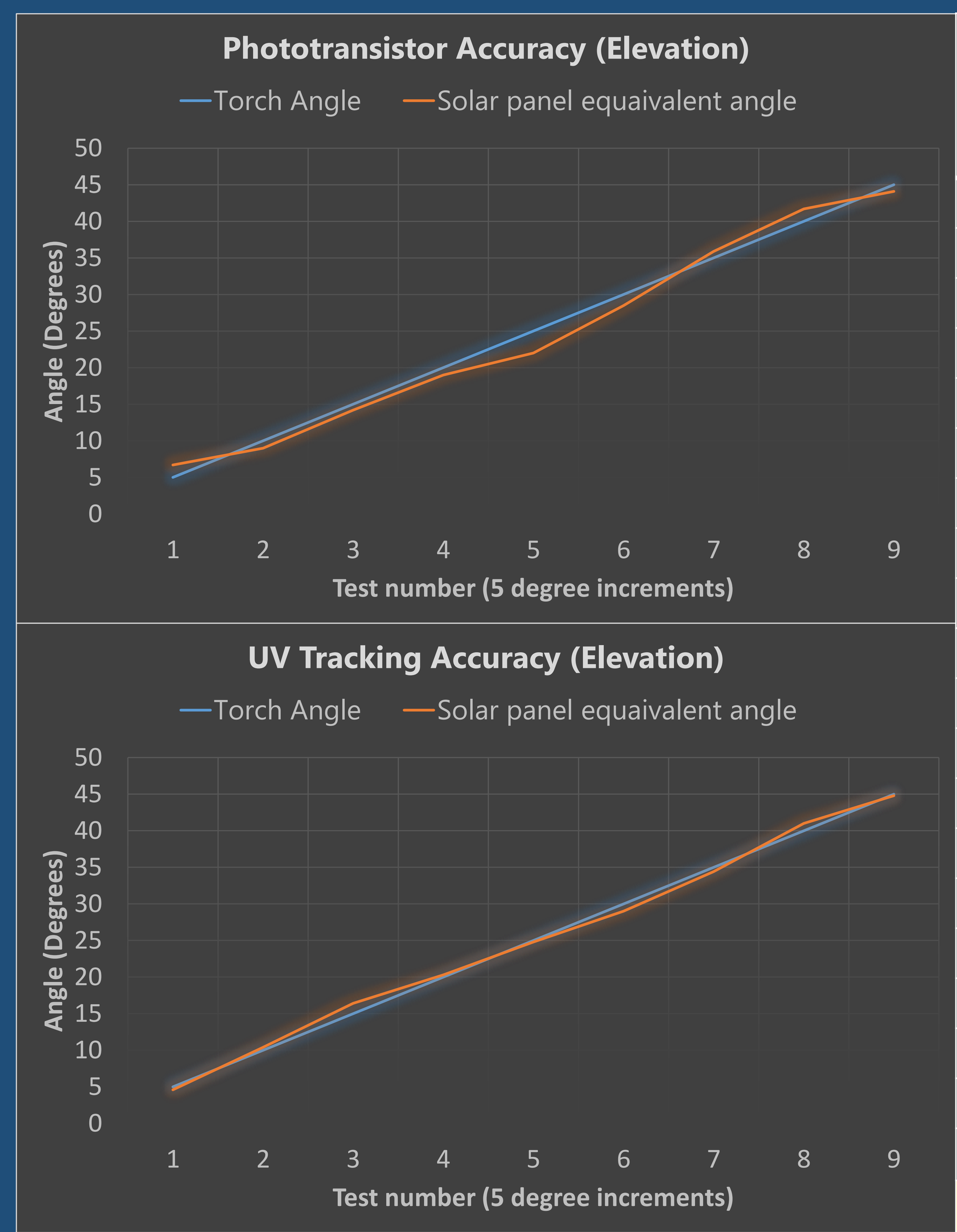
The sensor values are summed as highlighted above, and the difference between them indicate the direction of light. This is achieved using a microcontroller which reads the output voltages of the sensors which relates to the amount of light detected. It then finds the sum and difference of the sensors using the above to find the sun horizontally and vertically. This method is used for both the phototransistors and the UV sensors.

Completed Hybrid Tracker

See figure 5. The hybrid tracking system includes:

1. Operational amplifier circuitry – Reduces the effects of noise on sensor readings
2. Motor driver circuit- To drive stepper motors required for actuation
3. Charge controller circuit– Distributes solar energy to power the system and charge batteries.
4. Arduino microprocessor – Used to process sensor data and control the actuators.
5. Mechanical structure – Allows the solar panel to rotate and track the sun.

The Results



Test	UV tracking to phototransistor tracking time (s)
1	0.44
2	0.33
3	0.34
4	0.6
5	0.34
6	0.73
7	0.4
8	0.29
9	0.53
10	0.4
11	0.32
12	0.27
13	0.71
14	0.46
15	0.34
16	0.53
17	0.53
18	0.8
19	0.47
20	0.27
Average time (s)	0.455

Fig. 6

The results in figure 6 indicate that the UV sensors provide an improvement in tracking accuracy, and therefore will provide an increase in solar power generation. The phototransistors also took control of tracking if a sudden change in light direction occurred as can be seen in the table above. They took over tracking in an average time of 0.46 seconds and provided faster tracking compared to UV sensors. Therefore, with further development and testing, hybrid tracking may be applicable for use with vehicles as the tracker is both responsive and accurate.