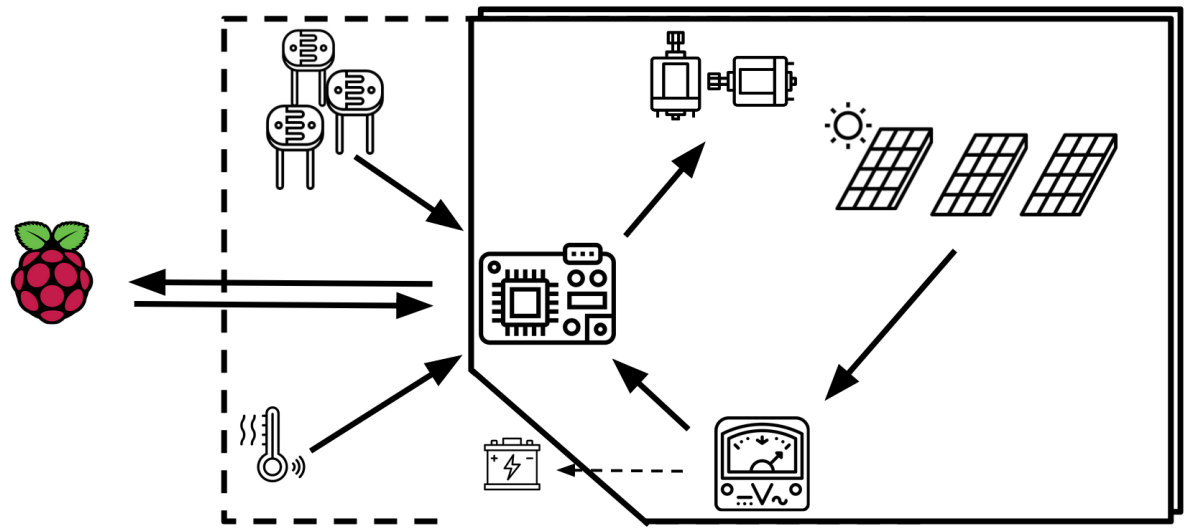
Mobile Solar Panels

Motivation

This idea describes the development of small mobile solar panels that can be deployed without additional calibration by the owner. They should be able to automatically adjust themselves to the sun orientation to capture the maximal amount of sunlight possible. The total number of solar panels should also be adjustable to increase the generated output due to their modular setup. This allows its users to immediately and continuously benefit from the device compared to a manual setup, in which the solar panels have to be constantly moved to maximize the energy output.

Description

The microcontroller should receive sensor data from the photoresistor modules in order to find out the current position of the sun corresponding to the solar panels. The modules have to be oriented in different angles to triangulate the position by small changes of the light intensity. This information will then be utilized by the microcontroller to turn the stepper motors with the solar panels, so they are directly facing the sun. The data of the photoresistor modules together with a temperature sensor can calculate the estimated amount of energy. This will either be confirmed or denied by a voltage and current sensor, indicating whether the solar panels work properly. The above setup describes one solar panel platform, which can be combined multiple times to increase the energy output. The data of these platforms will then be sent to one edge controller that aggregates the data and sends it to a cloud for storage and visualization.



Challenges

We expect to encounter the following main challenges during the project:

- Detect angle and direction of sunlight and align the solar panel accordingly
- Build an anomaly detection that reliably notices negative impacts from external (e.g. mud) and internal (e.g. damage) sources

Additionally, we set ourselves the following side objectives:

1. Minimize energy usage through
    - chosen hardware components
    - ESP sleep when possible
    - minimization of platform rotations
2. Adjust to requirements from renewable energy sources: Postpone energy consumption to points in time when more energy is available from the sun
3. Minimize network traffic through
    - protocols that are optimized for embedded systems
    - aggregate data on the edge before sending it to the cloud
4. Automatic cable wound-up prevention when rotating

Evaluation

- Mount light sensor on solar boards or on the ground
- Are two rotational axes worth the effort or is one sufficient
- Calculate motor control operations on IoT node vs. on Edge node
- Does it scale under the assumption that, regardless of the panels count, only one edge node is required? For instance, do we need more power than available from solar panels?
- Better with or without battery? (Endurance, power consumption, battery lifetime)

Sprint Plan

Sprint 1 (03.06.2022):

- Set up a minimal prototype solar panel platform
- Start implementation for automatic rotation of solar panels to sunlight

Sprint 2 (17.06.2022):

- Finish hardware setup (e.g. sensors for anomaly detection and observation)
- Finish implementation for automatic rotation of solar panels to sunlight

Interim Demo (24.06.2022)

Sprint 3 (08.07.2022):

- Implement anomaly detection
- Perform data aggregation at the edge

Sprint 4 (22.07.2022):

- Set up a cloud environment, store and visualize the aggregated data

Final Demo (29.07.2022)

Hardware Requirements

We optionally plan to build a second solar panel platform to be able to better demonstrate the distributed, mobile and modular nature of our design.

Additional required hardware is marked with a red asterisk (*).

Hardware	Amount	Reason
Mini solar panel*	1x per solar panel platform at minimum, several if possible	Energy production
ESP microcontroller	1x per solar panel platform	Sensor calculations and motor control
Stepper motor*	2x per solar panel platform	Rotating the solar panels in two axes
Raspberry Pi Zero*	1x	Data aggregation, visualization, and anomaly detection; Zero is preferred over other Raspberry Pis due to lower power consumption
Photoresistor module*	1x per solar panel platform	Sun position detection and estimated energy production
IR distance (preferred) or photo interrupter*	1x per stepper motor	Cable wound-up prevention
Temperature sensor*	1x	Anomaly detection / estimate energy production
Current sensor*	1x per solar panel platform	Measurement of generated power, anomaly detection
Voltage sensor*	1x per solar panel platform	Measurement of generated power, anomaly detection
Battery	1x per solar panel platform	Required for ESP, initial rotation