Module 2: Solar Tracker

In order get the most from solar panels, it is important to capture as much direct sunlight as possible. In the southern hemisphere, we point our panels North and optimise the tilt for our latitude (as well as ensuring we have minimal obstacles between our solar panels and the sun). However, the sun moves from East to West every day and seasonally changes from being high in the sky during summer, to much lower in the winter. Assuming we optimise the pitch for our location, we can achieve about 70% output from our panels over a year (keep in mind that's 70% of our $\approx$ 20% the panels convert to electrical power). Is there a way to increase this output? Yes there is! We can adjust the tilt each season and gain an extra 5%, or by tracking the sun across the sky during the day, we can change that 70% to 100%.

The purpose of this project is to program a control system for motorized solar panel and convince an investor to hand over huge sums of money so you can build it! The project is worth 10% of the total course marks, with the weighting being an even split between the physical implementation (5%) and the promotional booklet (5%).

This is a team project, each team should have a maximum of three members. It is up to you to select your team members, if you have trouble finding a team, please speak to one of the lab instructors.

1 Physical Implementation

This section outlines the details relating to the hardware and software required for module 2.

1.1 Hardware

For the control system hardware, each team will be provided with the following:

- RPI and motor driving shield
- Two servo-motors (signal sets shaft angle, not speed).
- A video camera. You can assume that solar panel is congruent with the plane of the camera.

1.2 Image processing

The purpose of the control system is to keep sun in the middle of the screen. There are two features of the sun:

1. It is red (always)
2. It is round (most of the time)

You can use either pixel colour detection algorithms (as in the Red Ruby project) or edge detection combined with shape extraction algorithms - it is your choice.

1.3 Controlling angles

Two servo motors are used, which drives the solar panel in azimuth and elevation directions.

1.4 Display

The system should display the image produced by the camera and also print the angles of which the camera is positioned.

1.5 Software assessment

The physical implementation marks are broken up as follows -

1. Control system tracks the sun on a white background: 30 %
2. Control system does not oscillate when sun is stationary (no energy waste): 20%
3. The system tracks the sun only when more than half of sun disk sun is visible: 15%
4. If sun is not found, the panel (camera) moves to the expected sunrise angle. At sunrise, the system starts tracking when half of sun disk is visible: 10%
5. System should work when it is installed on Mars (just in case) - the sun diameter is not fixed, the background is white: 15%
6. The system tracks the sun if another red object (not a circle) is present, for two scenarios:
   - The object is half the size of the sun 5%
   - The object is square and as big as the sun 5%

2 Promotional Booklet

Wow, your whole group are about to become millionaires. Believe it or not, you are the first people to ever come up with the concept of tracking the sun (yes, yes, use your imagination).

Now its time to convince an investor or government department to throw some money at your idea so you can build and test a full scale concept.

Your proposal needs a cover page with a photo of your tracker, and a catchy project name.

Your introduction should discuss the need for renewable energy as a future power source and why solar might have an important part to play (make sure the reader knows how important solar is for the future).

The next chapter should discuss how your prototype (that you designed in the lab) works. Remember, the reader might not be a computer scientist, in fact they may have very little knowledge of coding, so make sure you explain it in layman's terms.

The final chapter should talk about the scaled version you would like to design. Assume you will be sizing a tracker for a 300W panel (as shown in the figure below). The investor will be interested in how much additional energy your system will be able to generate. Your additional energy will need to consider not only the increase due to tracking, but also the energy used by the servos to track ($E_{in} - E_{out}$). So, assume:

- You have two 12V direct current (DC) servos
- Each draws 1A of current
- They have a 5 degree resolution (meaning every time the sun moves 5 degrees, the servo will follow)
- It takes the servo 10 seconds to rotate 5 degrees

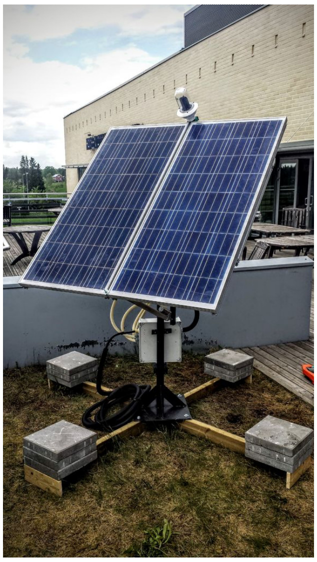
For calculating the energy increase, take the solar irradiance curve you found on the Summer solstice during your cabin project (technically you should use Winter, but hey, we're trying to sell this thing right?), work out the energy output of the 300W panel for the day, and assume a 30% increase in power for tracking compared to static (keep in mind, solar view gives you the available W/m^2 for a specific single tilt).

For the energy used by the servos, it's safe to assume the power draw of the "up and down" servo is negligible, so we will only need to calculate the energy used by the "left to right" servo over a day. For this, remember $P = V \times I$ and to calculate the energy used in a day, you just need to find out how long it draws power for in a day.

This chapter should also include a sketch/picture of your planed system and a rough budget. Make a list of what hardware you will need to purchase (think solar panels, servos etc) and pay your group for the hours you expect to work on the project

2.1 Promotional Booklet marking guide

1. Written language and references (20%):
   - Is the document easy to read and follow?
   - Are there minimal spelling and grammatical errors?
   - Are references included?
2. Layout and structure (10%): Is the document pleasant to look at and easy to follow?
3. Introduction (10%): Do you convince the reader of the need for solar?



4. Prototype description (30%):
   - How well is the concept of solar tracking explained?
   - Is the image processing described in a way the anyone could understand?
   - Does the prototype encourage the reader to invest in the concept?
5. Technical content (30%):
   - Do the calculations make sense?
   - Realistic sketch/drawing of the system
   - Rough budget

3 Submission for the Project

1. Your system will be tested during the last lab of the project period (see Software Assessment) - 5% of course marks.
2. The promotional booklet will be due on Friday of week 7 (September 6th) - 5% of total course marks