

ENGR290: Renewable Energy

Midterm Review

Feb 18, 2014

Matlab's best feature is its quick analysis of matrix data which allows you do very complicated operations with very simple code. What would take long programs in C or other languages is often reduced to simple and elegant statements in Matlab.

Example of vectorized matlab code to plot PV cell maximum power point

The voltage/current relationship of a PV cell is:

$$I = I_l - I_o[\exp(\frac{qV}{nkT}) - 1] \quad (1)$$

We need to create a surface plot of the power vs voltage at various temperatures.

1. Write a vectorized function to calculate the current:

$$I = pvCurrent(V, T) \quad (2)$$

2. Create vectors of inputs and expand them into a mesh.

$$V = [0 : 0.01 : 0.7] \quad (3)$$

$$T = [20 : 5 : 50] \quad (4)$$

$$[vg, tg] = meshgrid(V, T) \quad (5)$$

3. Calculate the current at all points on the mesh

$$ig = pvCurrent(vg, tg) \quad (6)$$

4. Limit the values to only positive numbers using logical indexing. This statement looks up all of the values of ig and uses that to index ig and set only those values to 0.

$$ig(ig < 0) = 0 \quad (7)$$

5. Reshape the ig vector. The result of the $pvCurrent$ call is a vector, but we need it to be the same shape as vg and tg so we can plot it.

$$ig = reshape(ig, size(vg)) \quad (8)$$

6. Calculate the power from the voltage and current. Notice the $.*$ operation does an element-by-element multiply (not a matrix multiply). Also note how powerful the syntax of Matlab is. One simple operation does what would take several for loops in C.

$$pg = vg .* ig \quad (9)$$

7. Plot the data using $surf()$ or $mesh()$

$$surf(vg, tg, ig) \quad (10)$$

Matlab program listing

```
function iPv = pvCurrent(v, t)
    % calculate the PV cell current as a function of voltage
    % and temperature
    %
    % v = voltage
    % T = temperature (celsius)
    Io = 1e-10;
    q = 1.602e-19;
    n = 1; % ideality factor
    k = 1.380e-23;
    Il = 2;
    temp = t+273.15; % convert to Kelvin
    iPv = Il-Io*(exp(q*v./(n*k*temp)-1)); % note the ./ for vectorization
end
```

```
function midterm_rev()
    % midterm review example function

    v=[0:0.01:0.7]; % voltage vector over which to calculate power
    t=[-20:5:50]; % temperature vector
    [vg,tg]=meshgrid(v,t); % create graph mesh
    ig=pvCurrent(vg,tg); % evaluate function
    ig(ig<0)=0; % limit to only positive currents
    reshape(ig,size(vg)); % reshape to size of the meshgrids
    pg = vg.*ig; % calculate power from voltage and current
    surf(vg,tg,pg); % plot the surface
    title("PV Cell power vs Voltage and Temperature")
    xlabel("Voltage (V)")
    ylabel("Temperature (C)")
    zlabel("Power (W)")
    print "-s800,600" "PVPower.png" % save image to disk for report
end
```

