EECS 16A Designing Information Devices and Systems I
Summer 2020 Discussion 0B

1. Energy Disaggregation

Recently, energy companies, such as PG&E, have put a lot of thought into a problem called *energy disaggregation*. The energy disaggregation problem is to take measurements of the total amount of electricity that a house uses and then try to determine which appliances are being used in the house. Energy companies want to do this because it allows them to better predict how much electricity they will need to produce on a given day, so they can offer suggestions to their customers on how they can save energy.

To get an idea for how this works, suppose you live in a very simple house with just an air conditioning unit, a refrigerator, and a television that all use power measured in watts. Suppose you want to figure out how much energy your TV, air conditioner and refrigerator use, but the only measuring device you have is the meter on the outside of the house that measures the total power the house is using. You can turn off the TV at any time, but you don't want to unplug the refrigerator because you don't want the food to go bad. The air conditioner stays off in the morning but then turns on in the afternoon.

(a) Design a method to determine how much power each appliance uses. How many measurements will you need to make?

Answer:

We need to get 3 sets of measurements, where each one has to give us new information. One such solution is to measure the power usage in the morning with the TV off (when only the refrigerator is running) and twice in the afternoon with the TV plugged in and unplugged.

(b) Write the system of equations you would need to solve this problem in terms of the unknowns (the power of the air conditioner x_{AC}, the power of the refrigerator x_{R}, and the power of the TV, x_{TV}) as well as the measurements you make of the total power (labeled T_1, T_2, etc.).

Answer:

The resulting three equations for the above measurements have the form:

$$\begin{aligned} x_{\text{R}} &= T_1 \\ x_{\text{AC}} + x_{\text{TV}} + x_{\text{R}} &= T_2 \\ x_{\text{AC}} + x_{\text{R}} &= T_3 \end{aligned}$$

2. Systems of Equations

Solve the following systems of equations, or if there is no solution, explain why. Can you visualize these geometrically?

(a)

$$\begin{cases} 2x + y = 6 \\ 3x - 2y = 2 \end{cases}$$

Answer:

There are many ways to solve systems of linear equations, here we will use substitution.

$$\begin{aligned} 2x+y=6 &\implies y=6-2x \\ 3x-2(6-2x) &= 2 \\ 7x &= 14 \\ x &= 2 \\ y &= 6-2(2)=2 \end{aligned}$$

(b)

$$\begin{cases} x+y+z=2 \\ x-y=1 \\ 2y+z=1 \end{cases}$$

Answer:

To solve this system of linear equations, we will begin by subtracting the second equation from the first equation.

$$2y+z=1$$

Notice that this equation is the same as equation 3. Therefore, the system of linear equations does not have a unique solution, infact it has infinitely many solutions.

The set of solutions can be described by a set of parameteric equations. To find the equations, we begin by chosing a parameter t, and set one of the variables equal to t, we chose z. Then we can write the other variables in terms of z and thus t.

$$\begin{aligned} &z=t \\ &y=\frac{1-z}{2}=\frac{1-t}{2} \\ &x=2-y-z=2-\frac{1-t}{2}-t=\frac{3}{2}-\frac{1}{2}t \end{aligned}$$

(c)

$$\begin{cases} 6x+2y=15 \\ 3x+y=7 \end{cases}$$

Answer:

Notice that if you multiply the second equation by 2, you obtain $6x+2y=14$. This is inconsistent with the first equation, as $6x+2y=15$, therefore there is no solution.