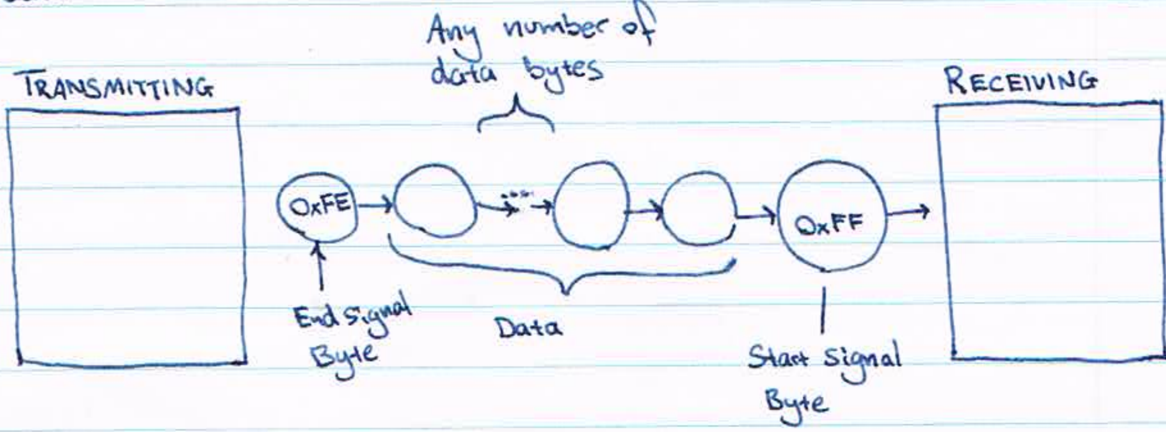
Mechatronics Project: Week 8

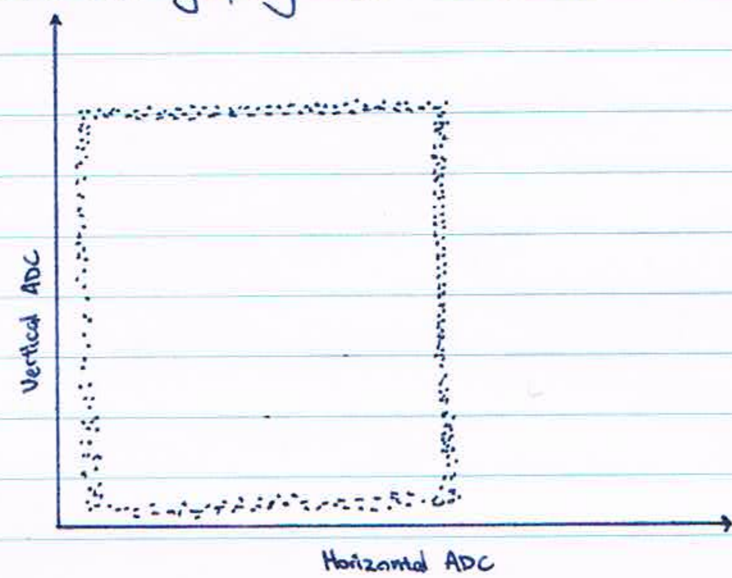
The communication protocol has two byte values that are dedicated to starting and ending a stream of bytes. In the example 0xFF signifies the start of a data stream and 0xFE signifies the end. Any number of bytes can be sent in between the start and end signals.

The receiving station should check the byte it receives to see if it is a starting or terminating byte before it attempts to process it as data

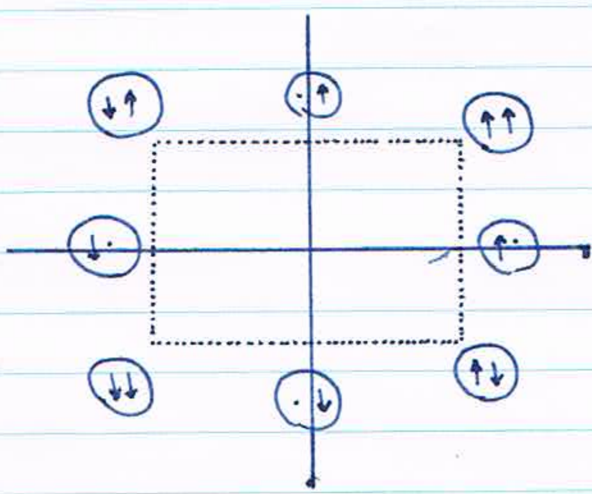


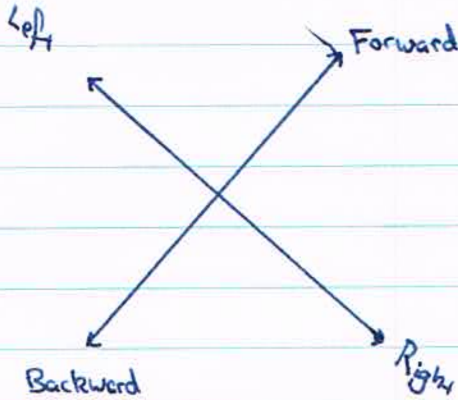
In the example program, the receiving station is expecting 2 bytes afte the start signal that contain the adc values. Since the adc values are 10 bits each and the byte has fewer than 8 bits of representation (after accounting for the values reserved for the start and end bytes), the values for the adc must be compressed. This can be achieved by dividing by 4 and reducing by 2 if the value still is greater than 253. The receiving station can choose to scale this back up if desired. Obviously there will be some loss in the resolution of the data because of the compression.

Sampling data from the horizontal and vertical channels of the Joystick and graphing them shows that the input space is square



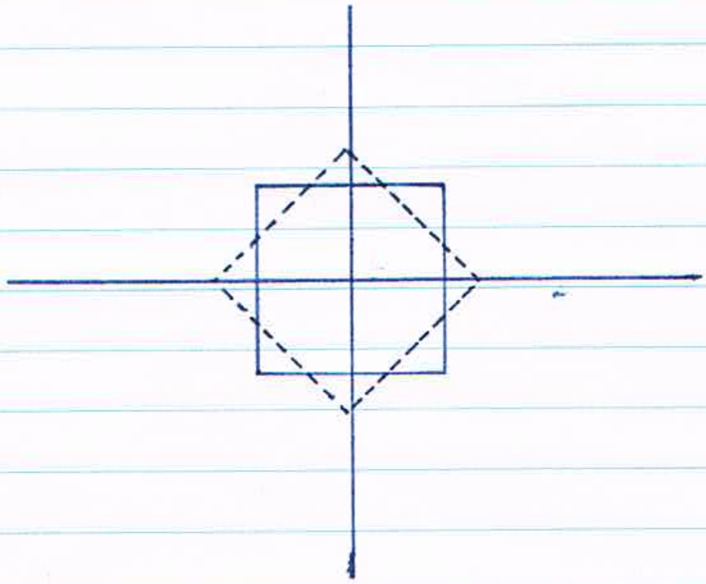
We can also notice that, if we assign the left and right motors a duty cycle proportional to the horizontal and vertical adc values difference from the mean, that Joystick mixing works as expected, albeit rotated 45 degrees from what is most intuitive.



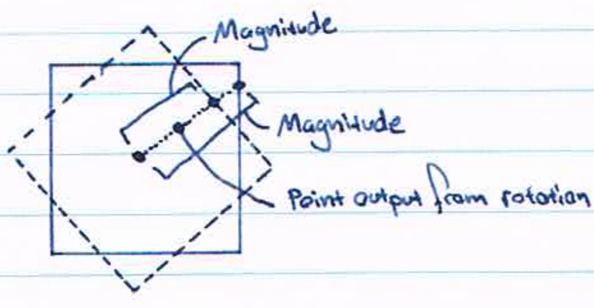


Ideally, we would just rotate our input space by $45°$ and use the new x and y values to assign the duty cycles. If we model the input as $z = a + bi$ where a and b are the horizontal and vertical adc values, we can rotate it by $45°$ by multiplying it by the complex number $\frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2}i$, which has a magnitude of 1 and an angle of $45°$.

The issue with this is that new input space doesn't overlap perfectly with the old input space. There are some values beyond what should be possible and some values that are unattainable.



It would be possible to scale up the output and then reduce it if it is outside the bounds, but that doesn't allow for as fine control of the input. Instead, we can calculate a scale factor for each point by calculating the ratio between the line segments that connect the origin to the points on the boundary of the input and output space, passing through the point whose scale factor we are calculating.



For the first octant, if our point resulting from the rotation is $z_0 = a_0 + b_0 i$, Then the line passing through the origin and z_0 is $y = \frac{b_0}{a_0} x$. We want to find the points when it intersects with the lines $x = d$ and $y = -x + d\sqrt{2}$ where d is ~~the~~ half the width of the square. This gives the points

$$\left(d, \frac{d \cdot y}{x}\right) \quad \text{and} \quad \left(\frac{\sqrt{2}d}{\frac{y}{x}+1}, \frac{\sqrt{2}d}{\frac{x}{y}+1}\right)$$

The scale factor for a point in the first octant is then

$$f(x,y) = \frac{\sqrt{\left(\frac{d \cdot y}{x}\right)^2 + (d)^2}}{\sqrt{\left(\frac{\sqrt{2}d}{\frac{y}{x}+1}\right)^2 + \left(\frac{\sqrt{2}d}{\frac{x}{y}+1}\right)^2}}$$

which simplifies to

$$f(x,y) = \sqrt{\frac{(y+x)^2}{2x^2}}$$

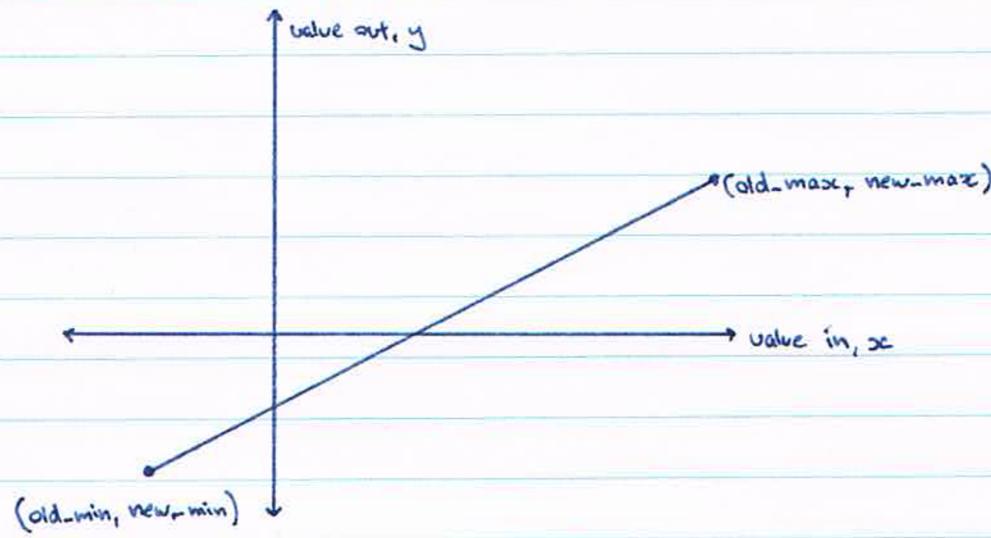
If we have a point in the second ~~quadrant~~ octant, we can use the symmetry along the line $y = x$ to say that -

$$q(x,y) = \begin{cases} f(x,y) & \text{if } x \leq y \\ f(y,x) & \text{if } x > y \end{cases}$$

We could use a similar fact to do the same thing over the x axis and the y axis, or more susscinctly

$$w(x,y) = q(|x|, |y|)$$

The 'squish' function takes a value and two ranges, a new and an old range. It returns a new value that is as if the old range was squished or stretched to the new range, and the inputted value was checked to see where it moved to.



If $y = mx + c$ then

$$\begin{bmatrix} 1 & x_{min} \\ 1 & x_{max} \end{bmatrix} \begin{bmatrix} c \\ m \end{bmatrix} = \begin{bmatrix} y_{min} \\ y_{max} \end{bmatrix}$$

$$\begin{bmatrix} c \\ m \end{bmatrix} = \begin{bmatrix} \dfrac{x_{min} * y_{max} - x_{max} * y_{min}}{x_{min} - x_{max}} \\ \dfrac{y_{min} - y_{max}}{x_{min} - x_{max}} \end{bmatrix}$$

We can then substitute in m, c and the value, x to find the function's output, y.