Ex 2.2 Fuzzy Controller

Source code located in Source directory

For the fuzzy controller, I have 3 major steps / developments. The first step in the process that I took was manually (by hand) drawing and designing the controller. The snapshots related to that process can be found at 1.1 below. I then computed manually by hand the estimated surface height at the two points. This portion can be found at 1.2 below. Next I plugged manual values into my controller to show and plot the surface that my manually derived surface produced. The plotted required surface, control surface from my controller, and the plotted error between the two can be found at 1.3 below. After using my manual design, I also decided to programatically derive the grid tiles to see if I could reduce the error rate.

Manual Design:
To design the manual controller, I first picked a set of singletons. I then estimated triangular memberships based on how the surface looked (changes in gradient). From there, the intersection of x triangular memberships and y triangular memberships were estimated using the singletons.

Translation to code:
The coded controller has x and y vectors which are translated into triangular memberships. The assumption made is that the midpoint between any 2 successive points belongs to 50% or .5 of each triangle. The other portions needed for set up is the output singletons and the actual function itself (For required surface, error calculation and optimization design). Each point is first fed to triangular memberships where Output Singleton values and degree of belonging are determined. From there, each estimated output can be achieved, plotted and compared against the actual surface.

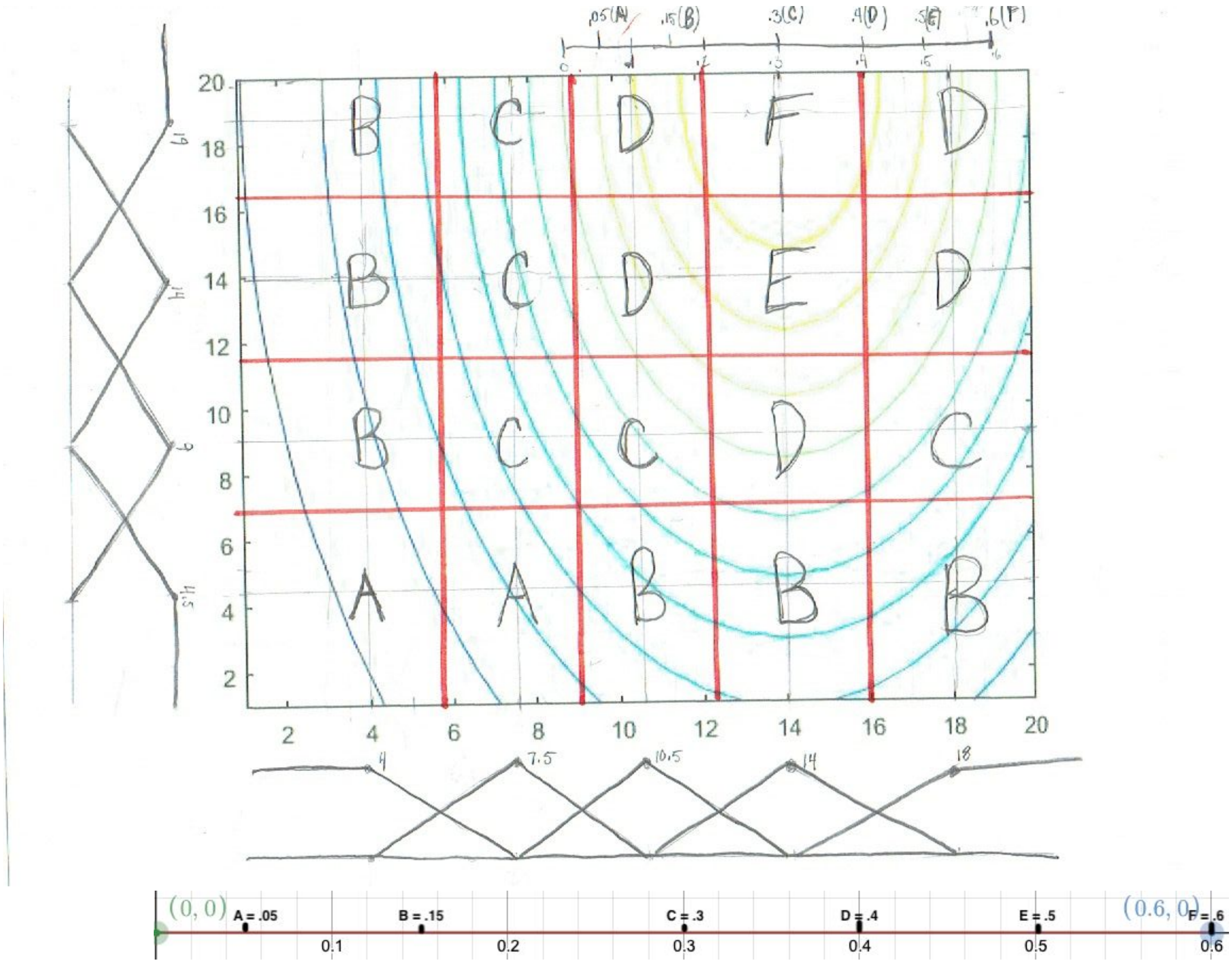
Optimized Design:
For the optimized controller, I used the same divisions that make up the triangular membership functions. I then ran each point through the given function and chose the closest output singleton value to the output and assigned the x-y intersection with that value.

Error Calculation:
The error was calculated by total error (Total errors from all measured points), as well as average error. The error for all designs were determined by selecting 30 x values and 30 y values, computing the control surface of designed controller, taking the distance from the required surface. For the first design, the calculated total error was 52.17 with an average error of 0.058. After optimization of the controller, the total error was reduced to 24.12 and the average error to 0.027.

Total Error = $\sum_{i=0}^{n} \sqrt{(required\_surface\_output_i - estimated\_surface\_output_i)^2}$

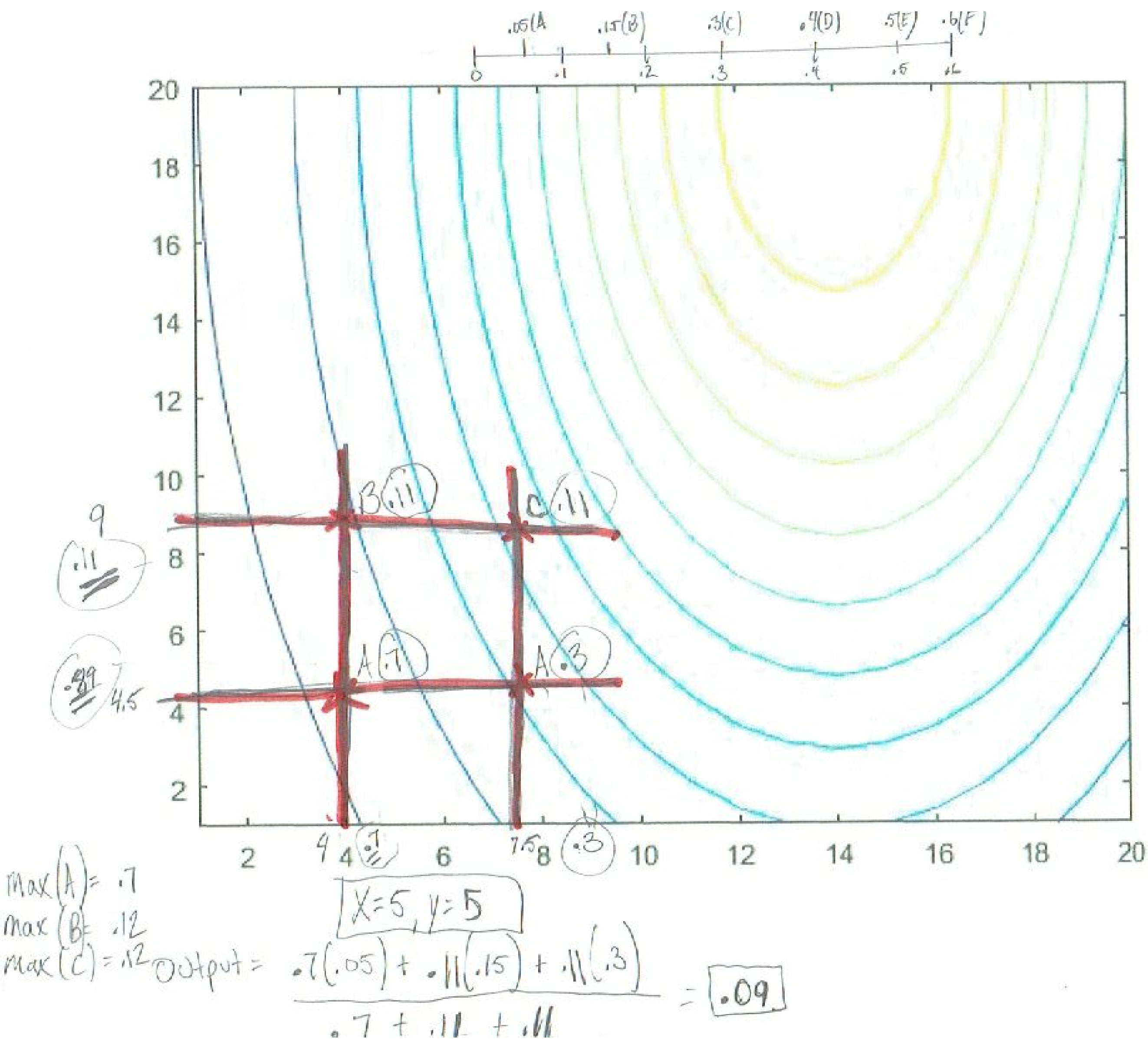
Average Error = Total Error / n   Where n=number of measured points.

1.1 Manual Design of Fuzzy Controller

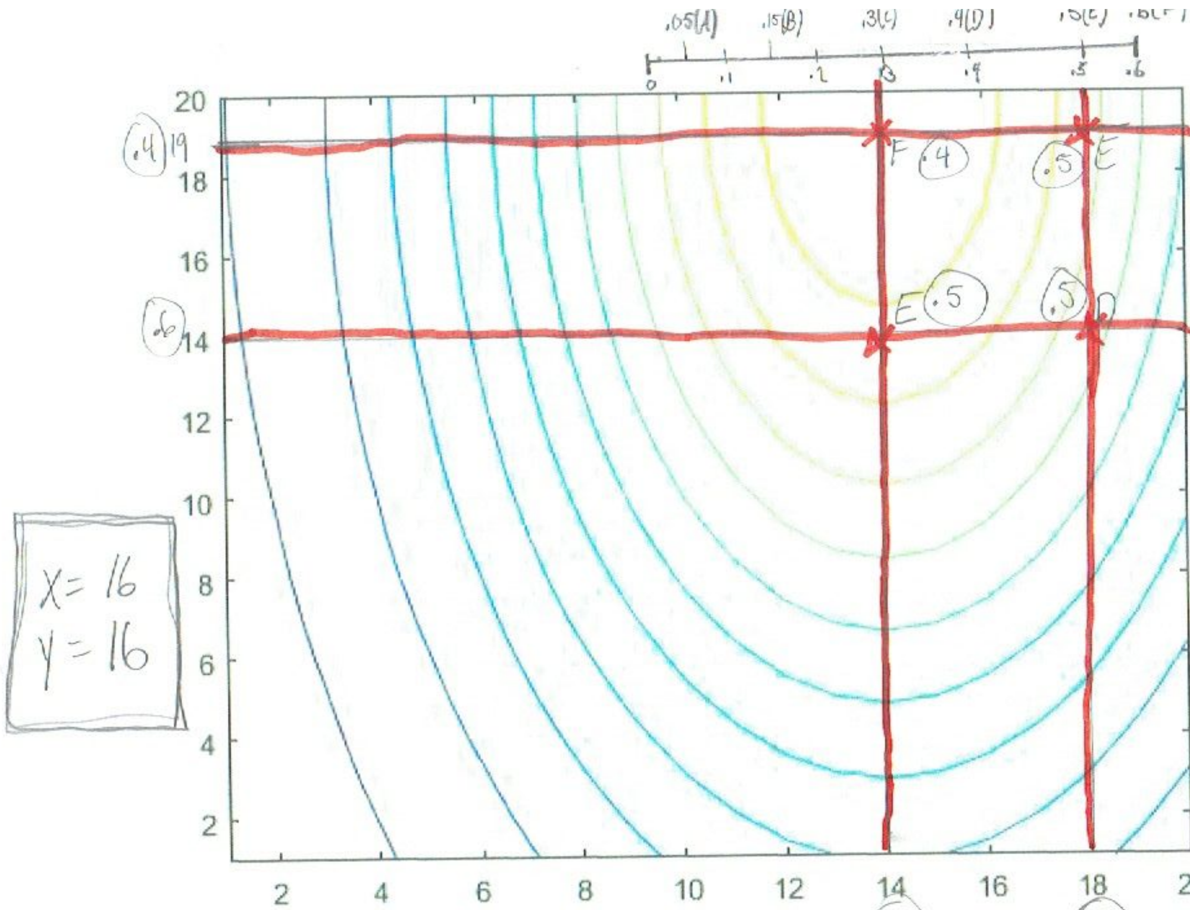


1.2 Controller Tested Manually at Two Points

Values (x, y) = (5, 5)
Manually derived output = .09



Values (x, y) = (16, 16)
Manually derived output = .53

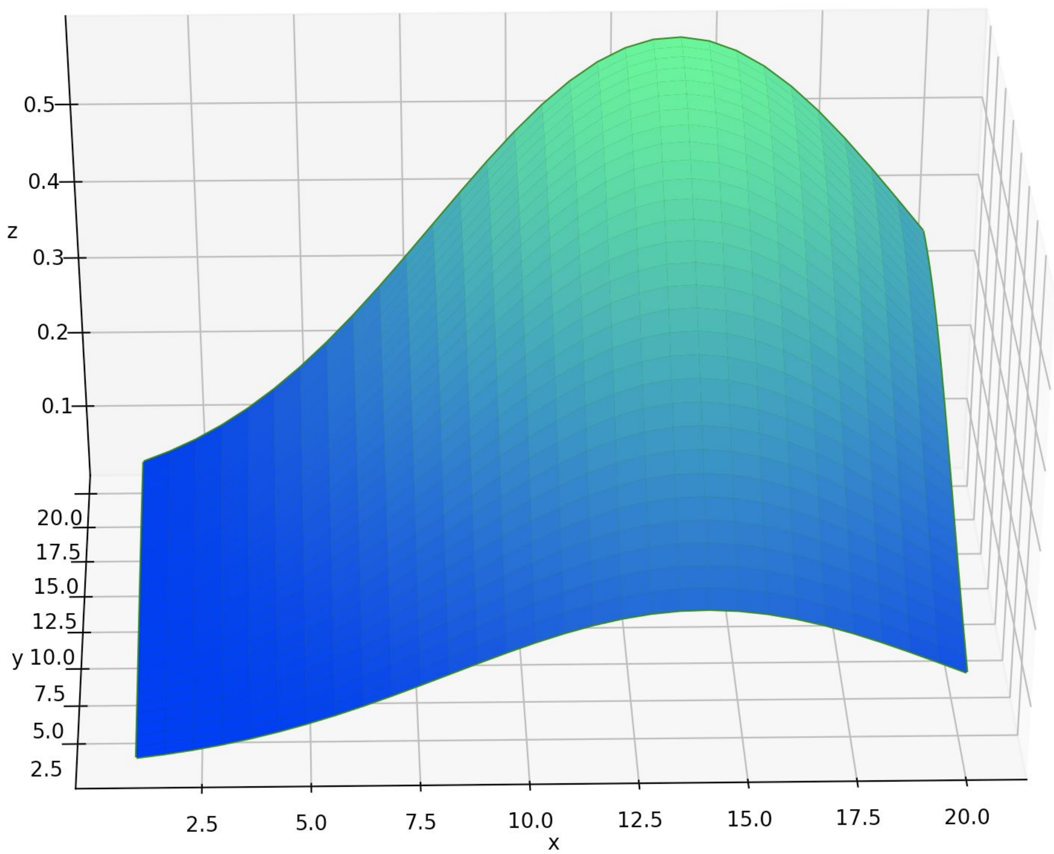


$$\text{Output} = \frac{.5(.4) + .5(.5) + .4(.6)}{.5 + .9 + .4} = \boxed{.53}$$

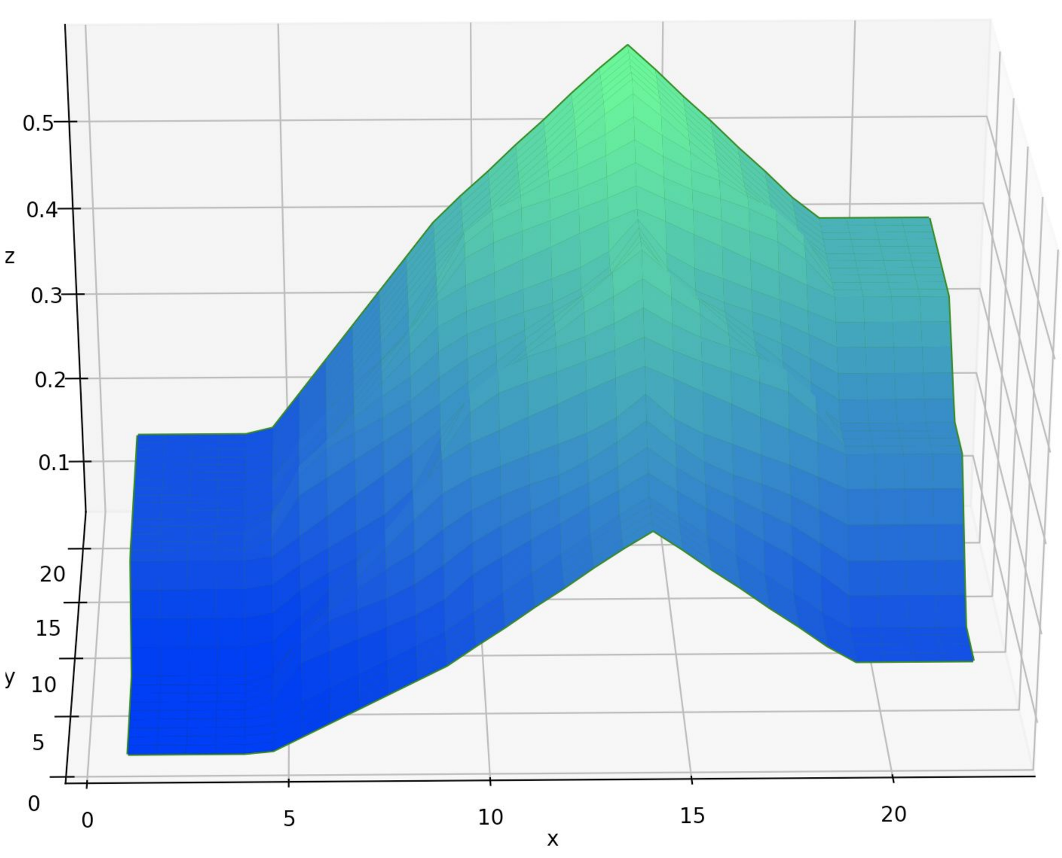
Max(D) = .5
Max(E) = .5
Max(F) = .4

1.3 Require Control Surface and Surface from Controller

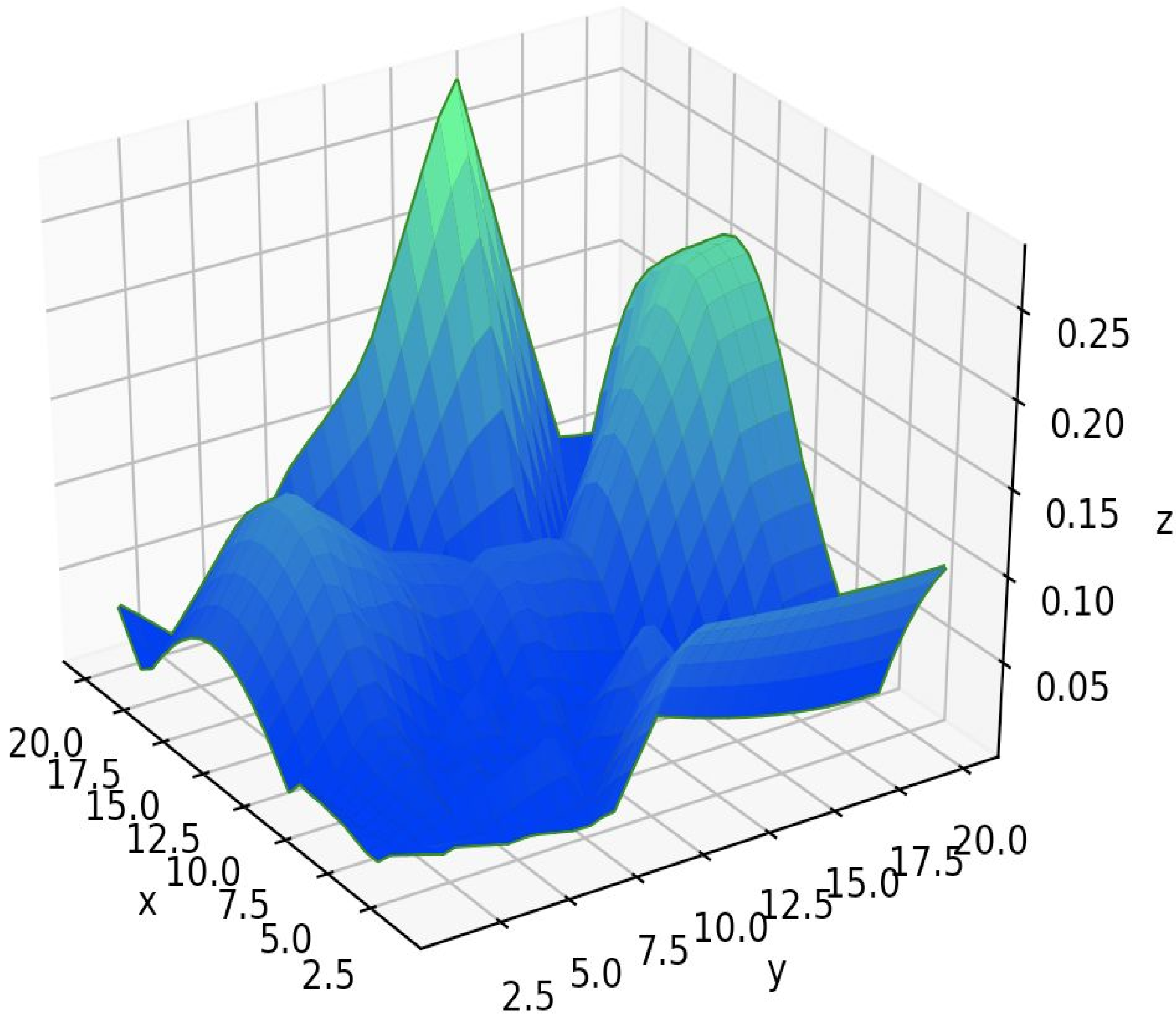
Required Control Surface:



Controller Produced Control Surface:



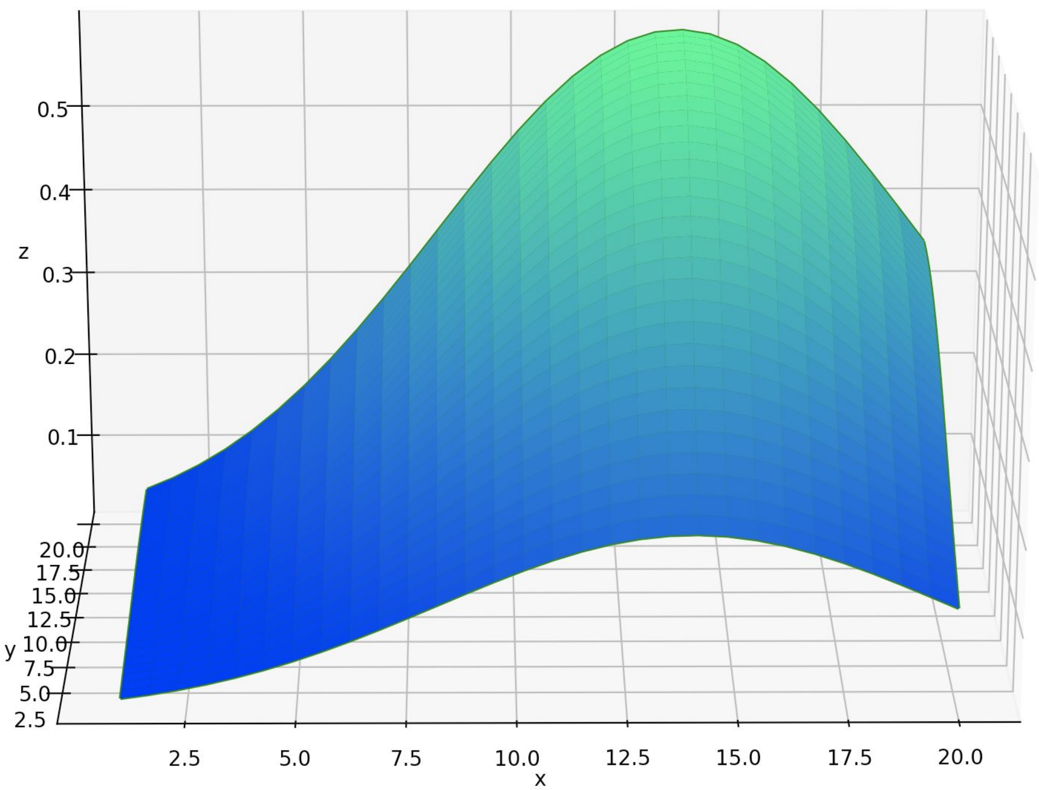
Surface Estimation Error:



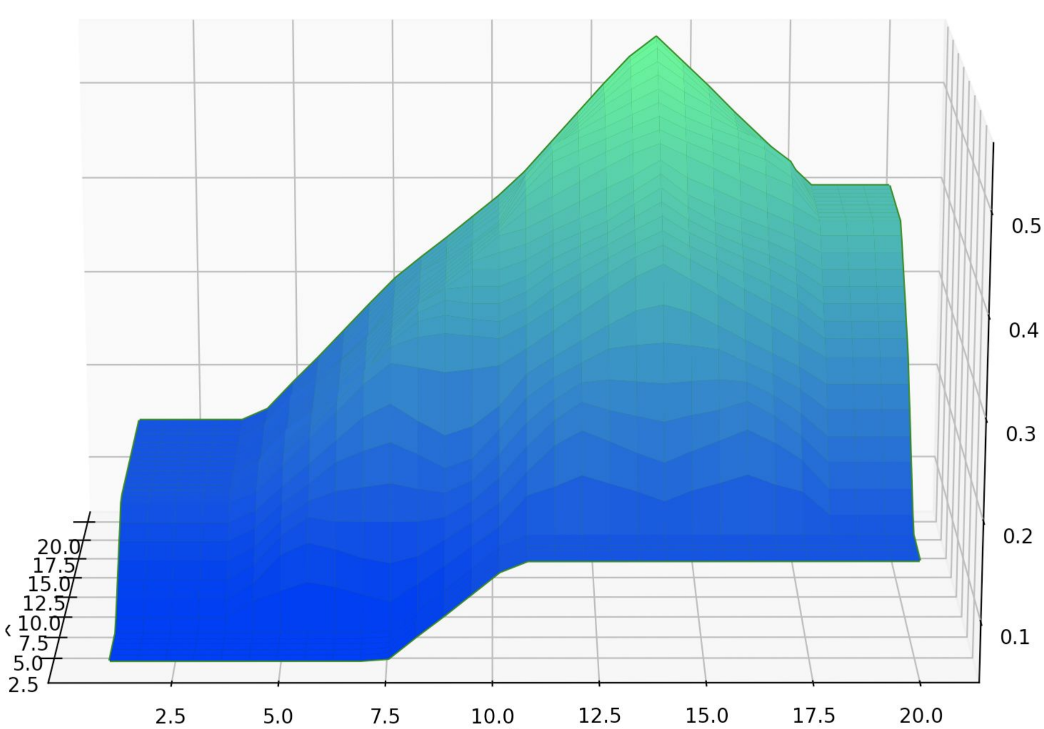
Total Error: 52.17
Average Error: 0.058

1.4 Optimized Control Surface

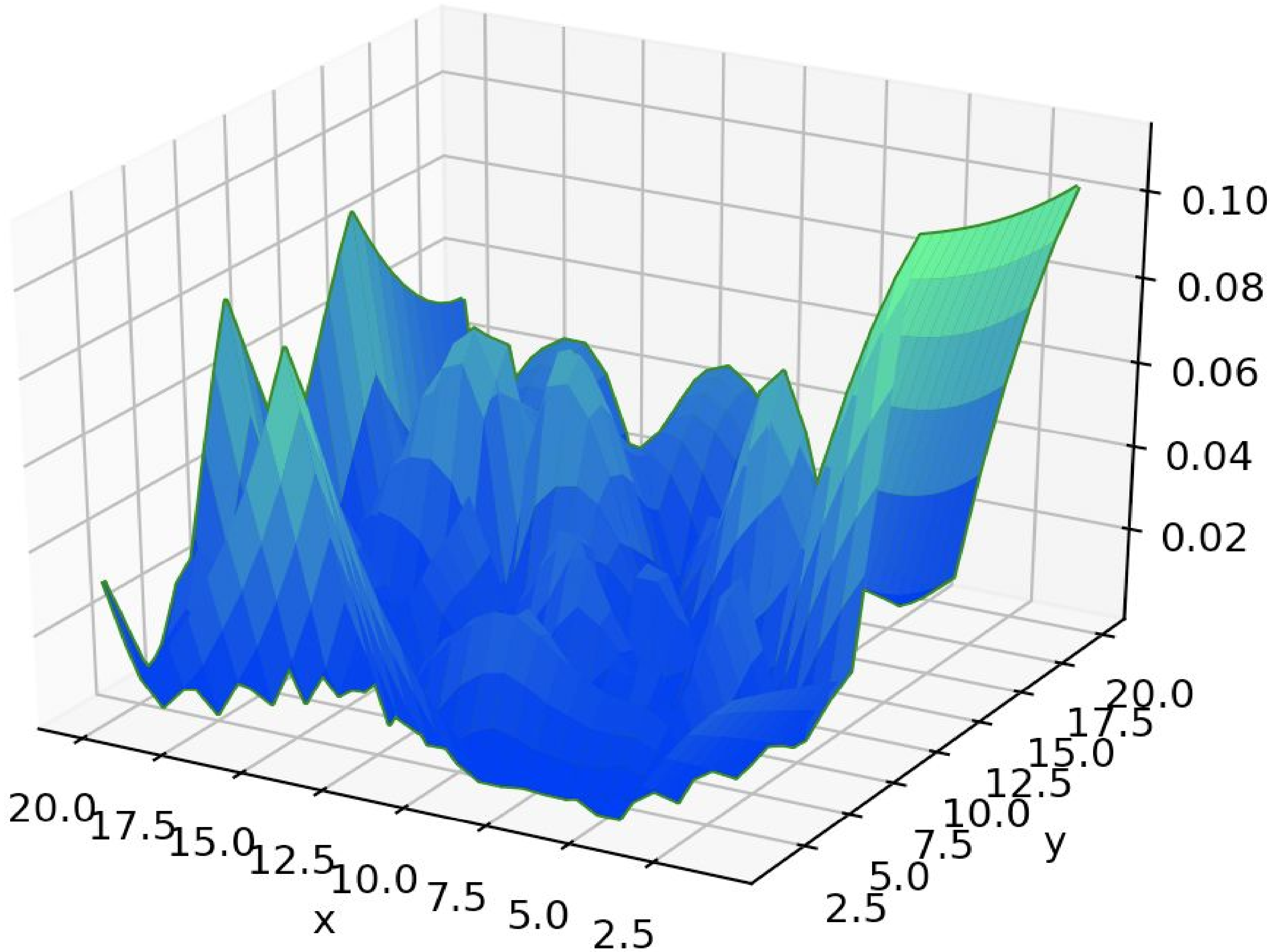
Required Control Surface:



Controller Produced Control Surface:



Surface Estimation Error:



Total Error = 24.48
Average Error = 0.0272

Grid for Optimized Controller