Computational Intelligence Lab 1

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2) Description of the membership functions that you have designed for the output variable and the rule base defined. Argue why you have chosen these memberships and rules.

There are three membership functions for the output. A positive motor output, negative motor output, and zero motor output. The negative is needed when the pendulum has a positive difference, and the positive is needed when the pendulum has a negative difference. Of course, the neutral is needed when the pendulum is in the correct place. A couple more membership functions to the output function could be added, such as a strong output and a weak output. The reason for not doing this, is due to the extra membership functions would cause more chances for errors when setting up the rules for the fuzzy logic controller. The extra rules would be correlate to the error derivative. So that if the pendulum is moving away, it could produce a strong output and if it is moving toward, it produce a weak output. Again, this was not chosen since it complicates the system unnecessarily.

The input functions were changed from trimf to zmf and smf. This was done so that all negative values would fall into the appropriate function. The controller will still be functional if the membership functions are changed back to trimf, but will require a lot of fine tuning to get all the values correct for the outputs so that the desired performance is reached. The fine tuning will have to be done on the output membership functions mainly so that the output strength is what is desired. The membership functions can be seen in Figures 1 and Figure 2 shows the rules that were used.

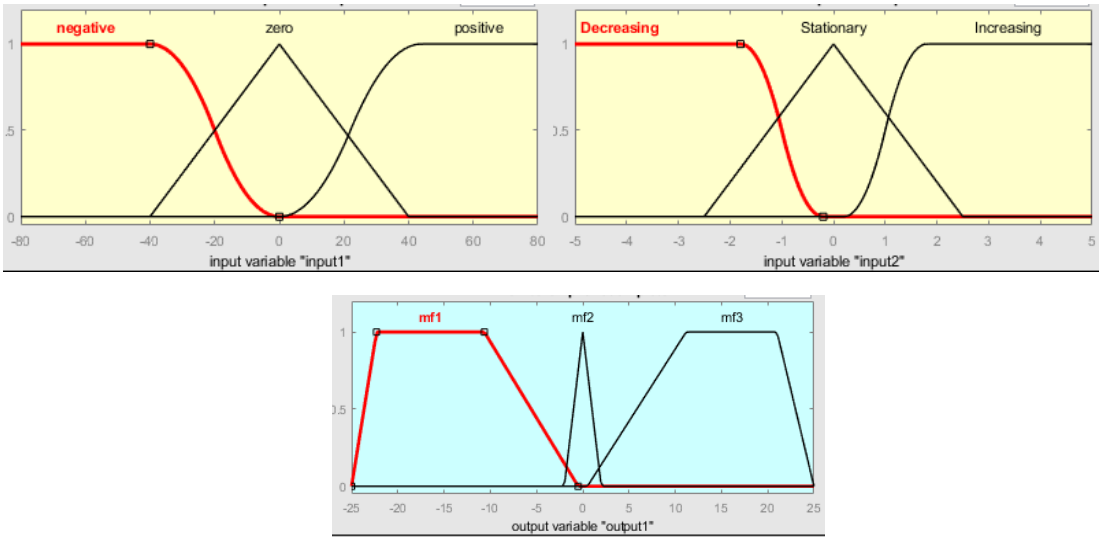

Figure 1. Membership functions (Theta- top left, Theta dot- top right, output- bottom)

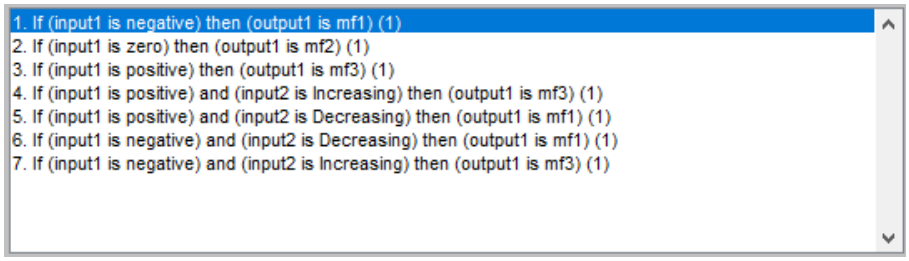

Figure 2. Rules

3) Plots of the results that you get for the following values with a simulation stop time of 80: 2.1) theta_ref = 20 and thrust = 0.123 2.2) theta_ref = -10 and thrust = -0.062 Write your own comments about the results that you get.

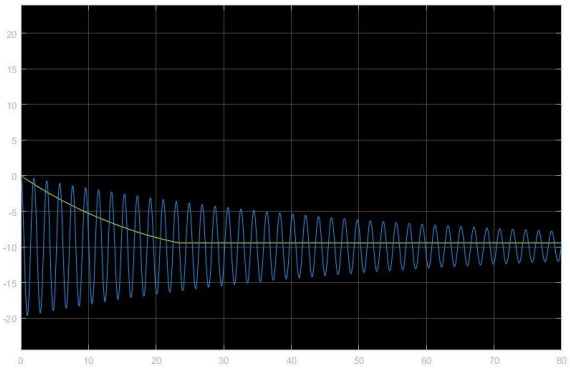

Fig 3. Desired Theta=-10

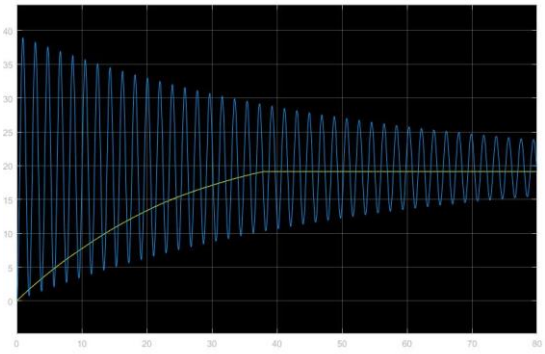

Fig 5. Desired Theta = 20

The fuzzy controller is clearly working. It is able to approach the desired angle without overshooting it and settles faster than the pure thrust method. The angle is not exact to the one desired, but this can be resolved with fine tuning the membership functions. The fine tuning will have to be mainly on the output values, but some tuning on the input memberships may be helpful as well.

4) What happens if you increase the number of membership functions (7 or more) of the output?

If there are more membership functions, then this will allow for more fine tuning of the system response. For example, you can have a strong output or weak output. These would be used with the theta derivative, so that if the derivative is large then a strong output could be used, while if the theta derivative is small then a weak output could be used. This is to help have more control of the pendulum as it nears the desired theta. It would also increase the complexity of the system and the number of rules being used. Currently, increasing the number of rules will not be helpful. This is due to the cases not being covered by the current rules happen at such small moments of time, that the affect of the will not be great. For example, the case that the pendulum has a negative error and the error derivative is zero, will only happen when the pendulum has either started from the position at rest, or when it is approaching the end of its arc. Having a small adjustment at those point may be helpful, but is not necessary for the system to work, and the benefits are likely to be negligible.