EBS 289K

Homework 3

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Part 1:

Part 1 is the implementation of the pure-pursuit and the combination of my bicycle model and the pure-pursuit. They can be running directly in my hw3.m file.

Ending condition: If the closest point is the last point of our path, my tractor will stop. It would be better to add an epsilon to control the distance between my tractor and the last point in the ending condition. However, if I use a hard code to set an epsilon, it may never stop if I need to generalize those code to other path in the future. I decided not apply distance epsilon this time.

Part 2:

Here are the robot's trace and error:

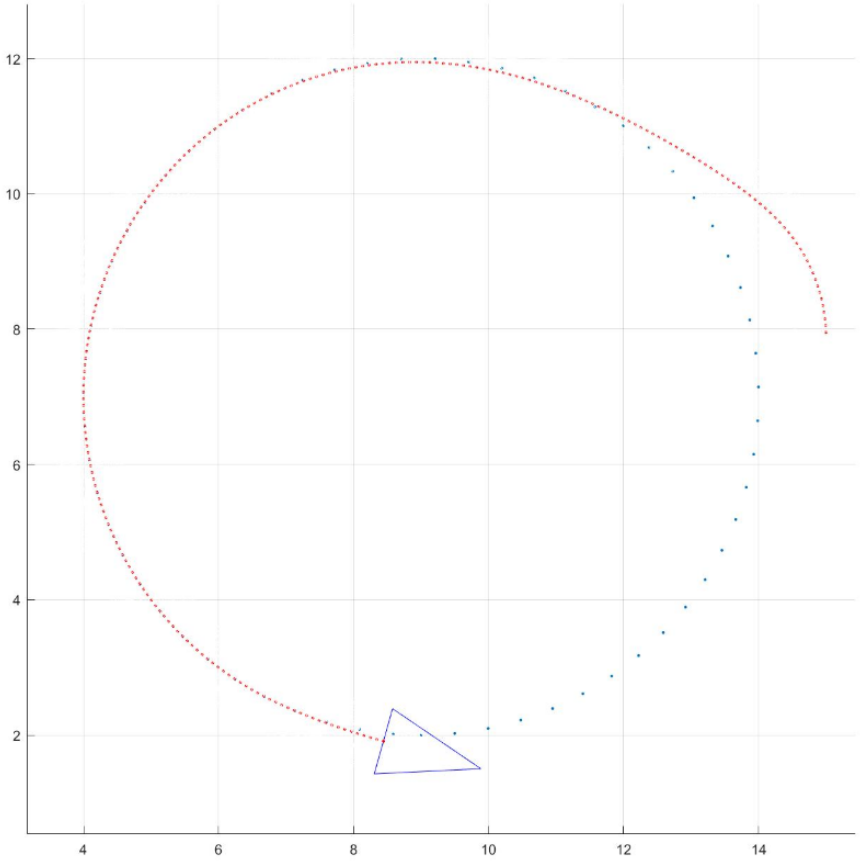

Figure 1: the circle trace of the tractor

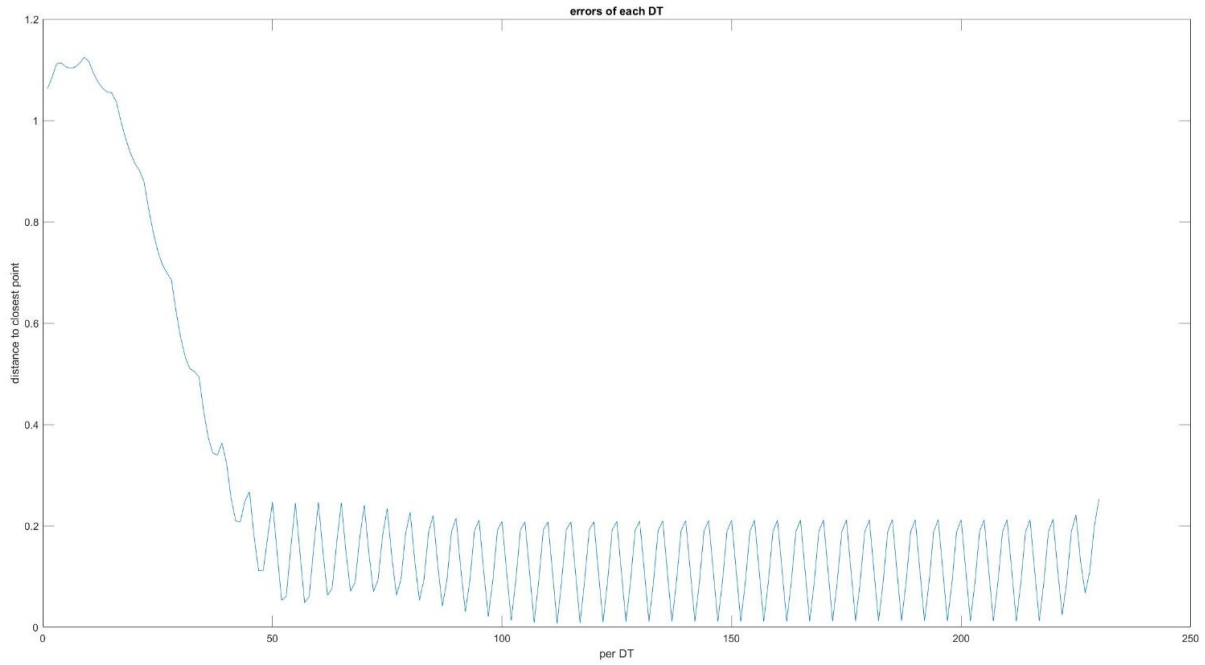

Figure 2: errors of the circle trace

Question: Why is the tracking error nonzero, whereas the robot path looks good?

Answer: The method we used to calculate the error leads to nonzero errors. In this case, an error is the Euclidean distance between the current position of our tractor and the position of its closest point in the path. Since the path points have a different interval compared with our tractor, the error cannot be zero even we are running in the right direction.

Question: How can you improve the error calculation?

Answer: A better way for us to improve the error calculation is to generate some new points based on interpolation to feed gaps between path points. Those points describe the path more precisely, then they can be better land marks for us to calculate errors.

Part 3:

When Ld is still 2, here are the trace, errors figure and the error histogram.

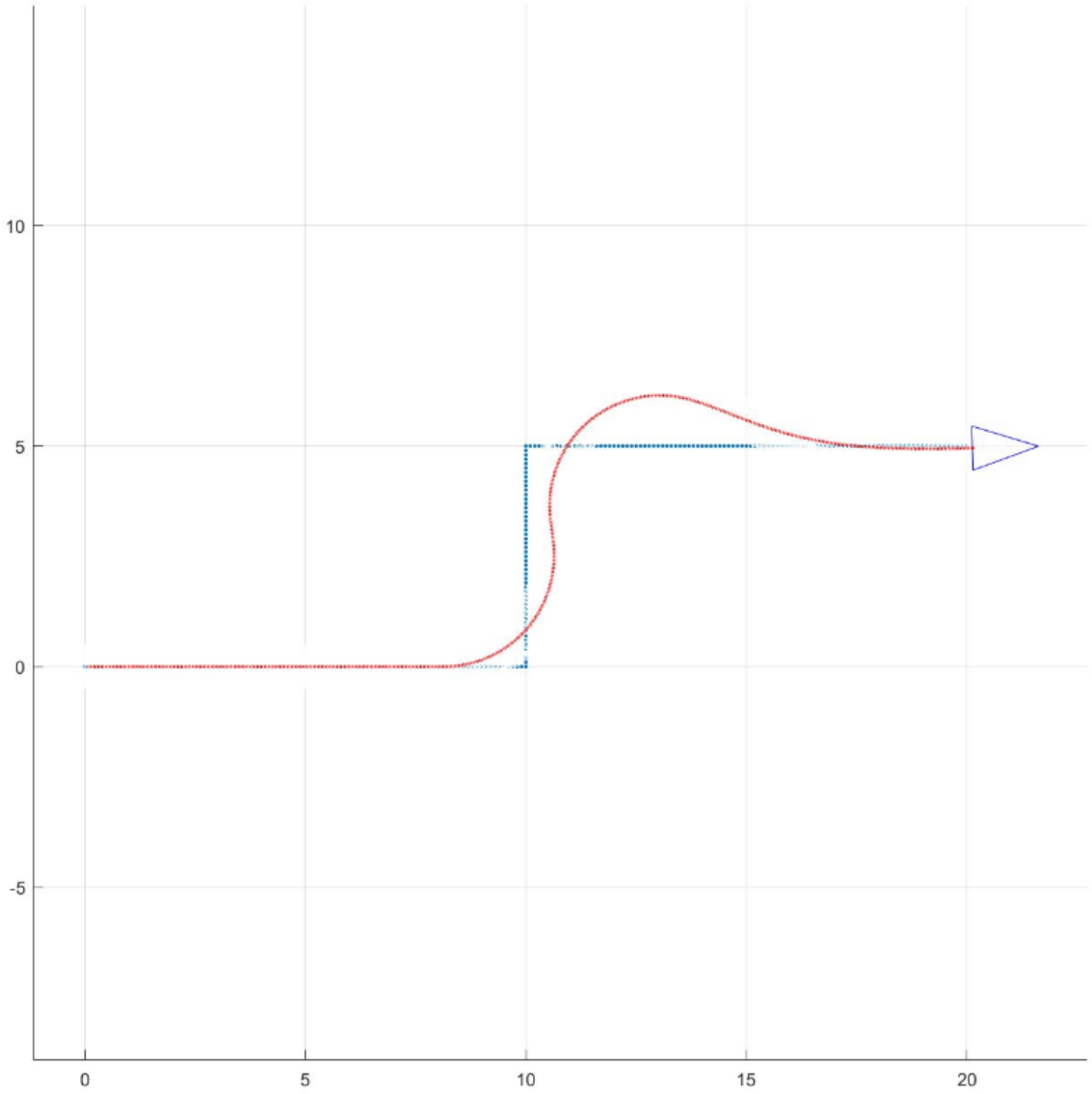

Figure 3: the trace of step path with Ld = 2

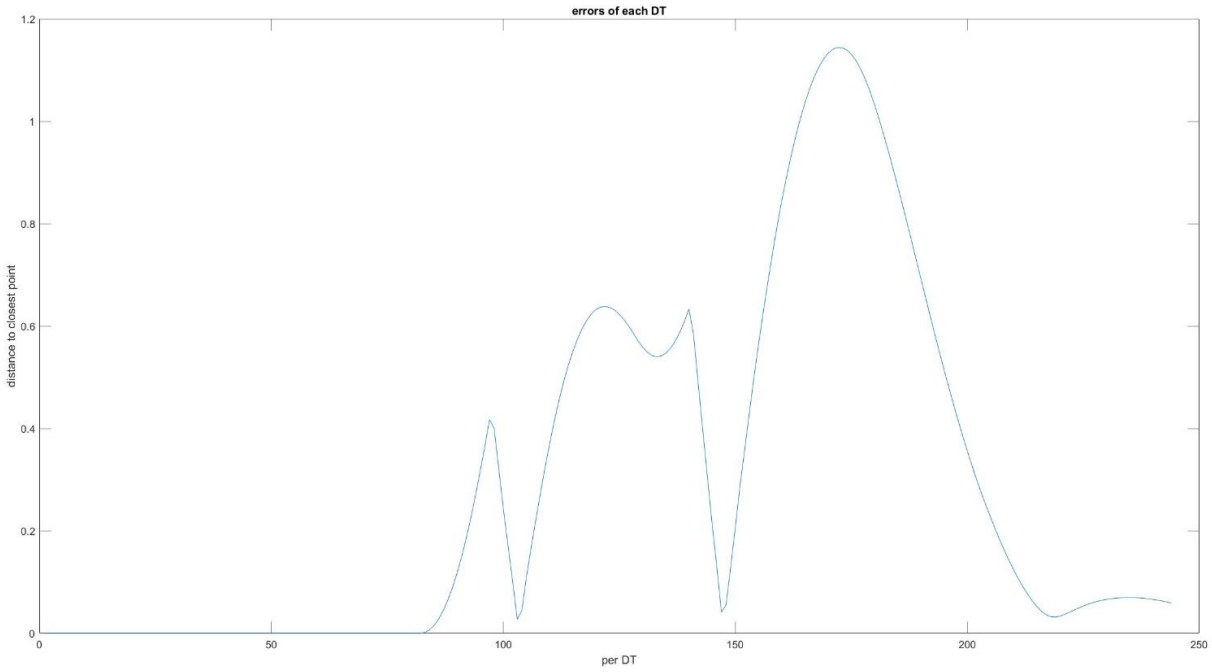

Figure 4: errors of the step trace

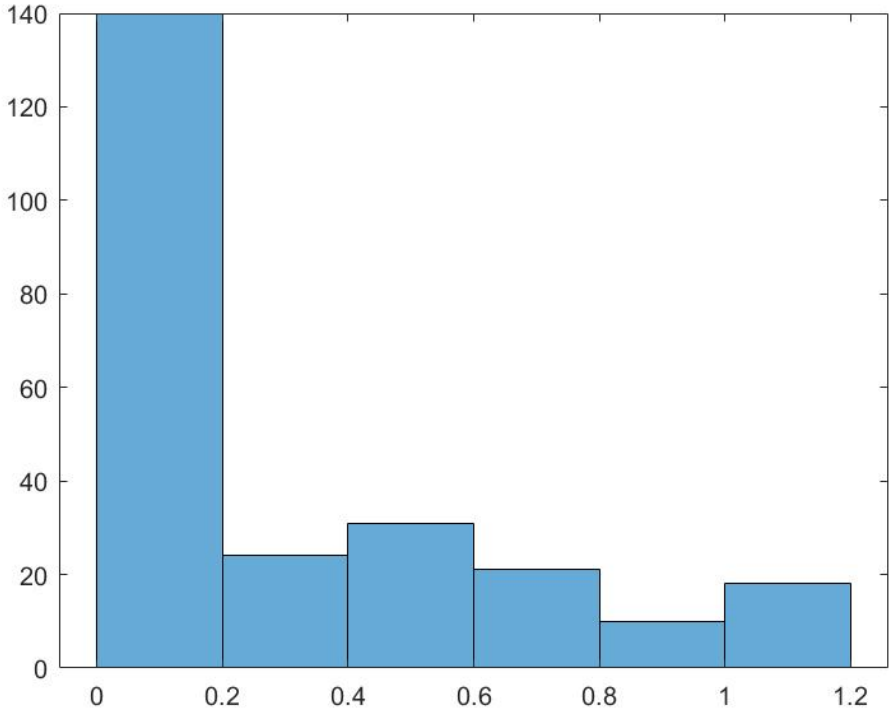

Figure 5: histogram of errors in the step trace

Now, let's try different Ld with 1 and 3 and see if there are some differences.

Here are results with Ld = 1:

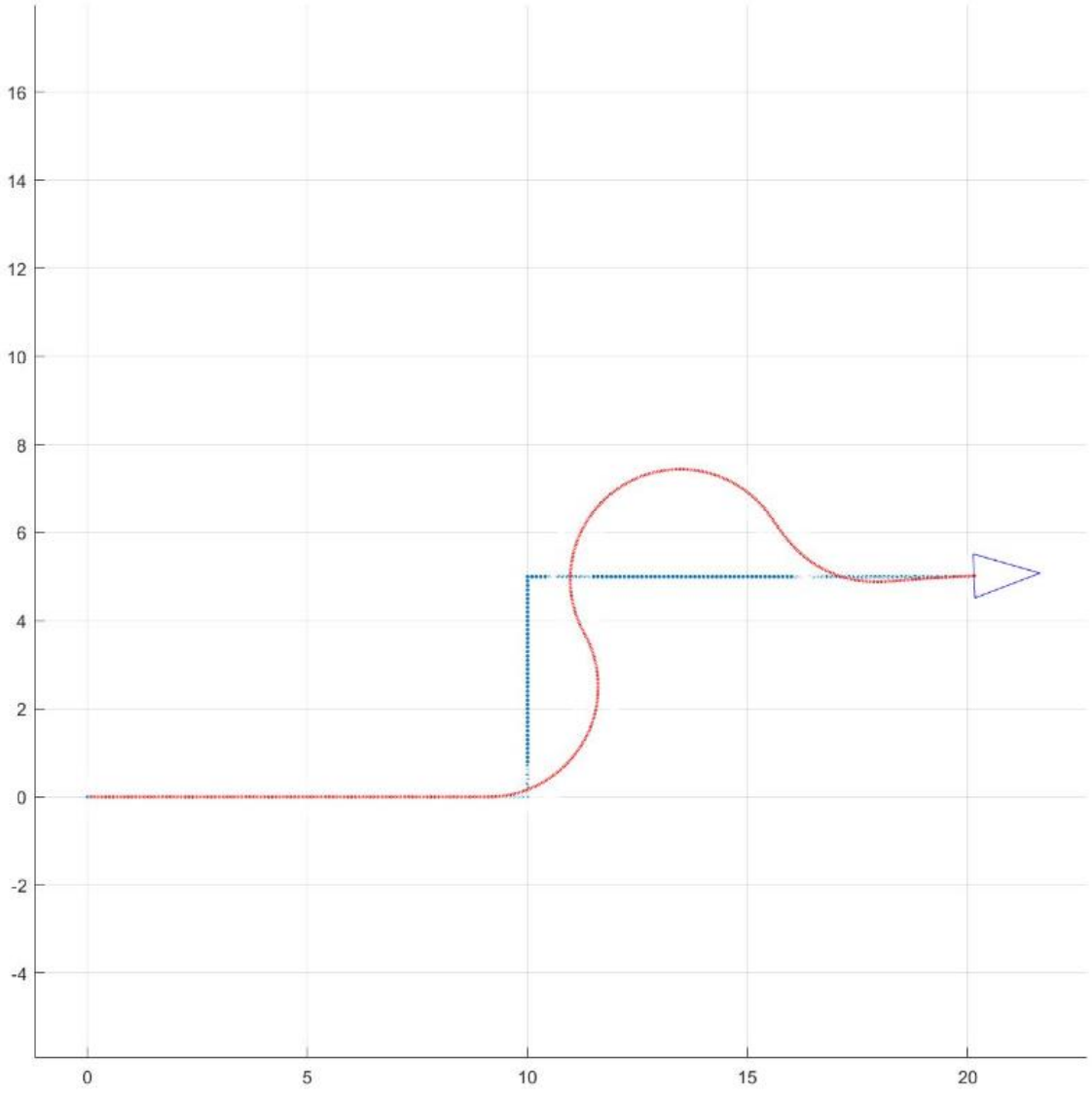

Figure 6: the trace of step path with Ld = 1

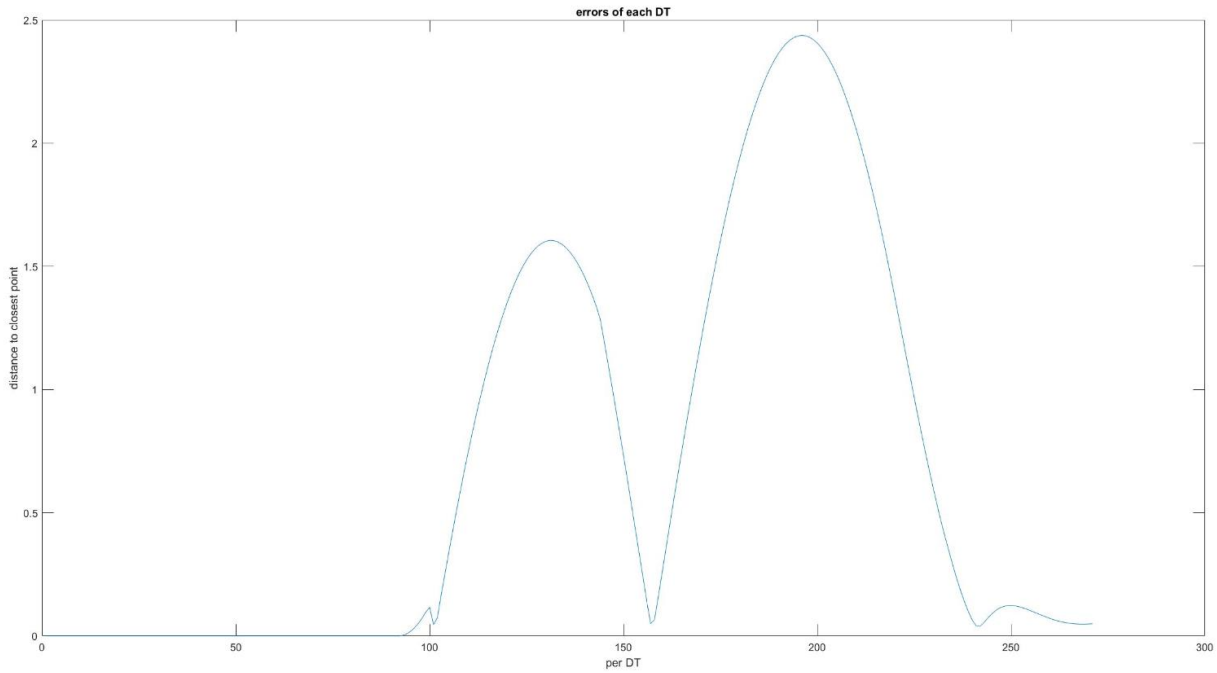

Figure 7: the errors of step path with Ld = 1

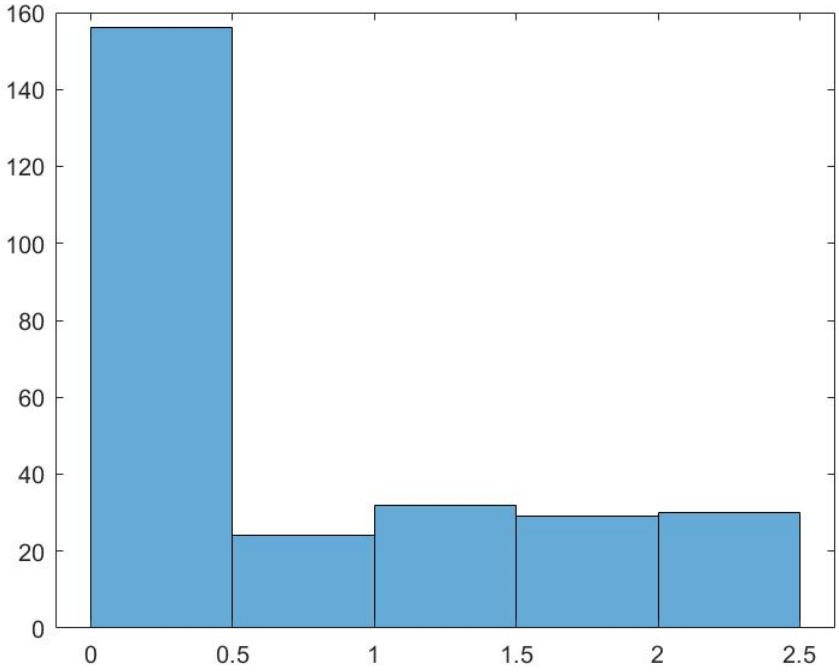

Figure 8: the histogram of errors in step path with Ld = 1

Here are results with Ld = 3:

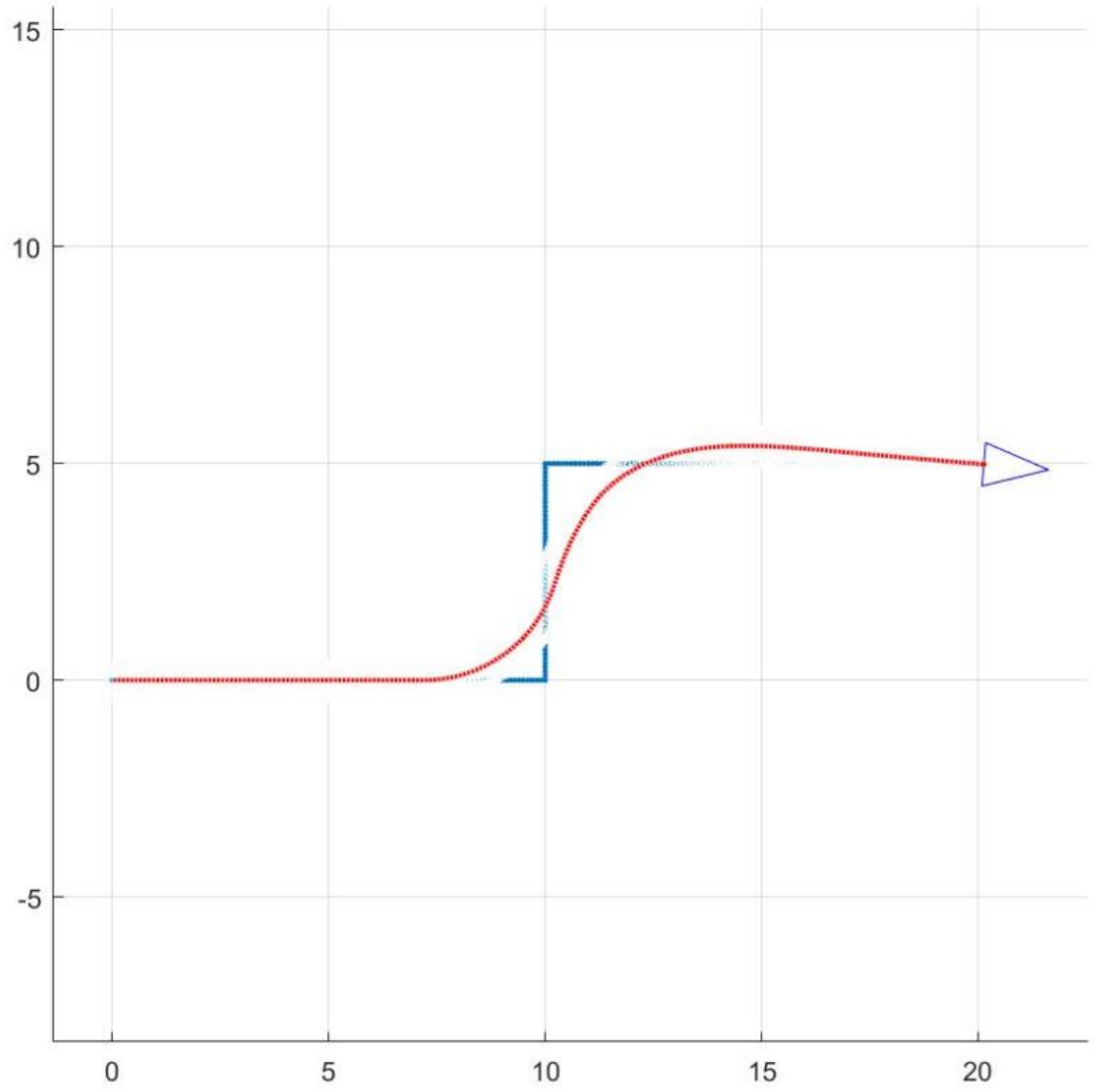

Figure 9: the trace of step path with Ld = 3

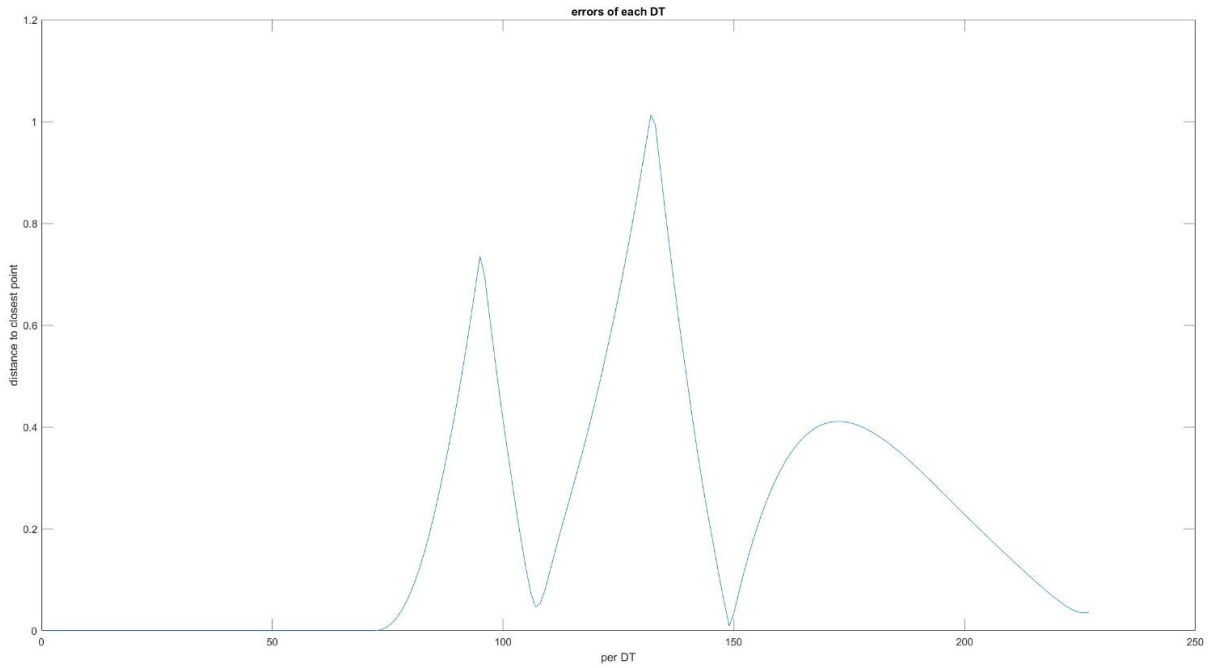

Figure 10: the errors of step path with Ld = 3

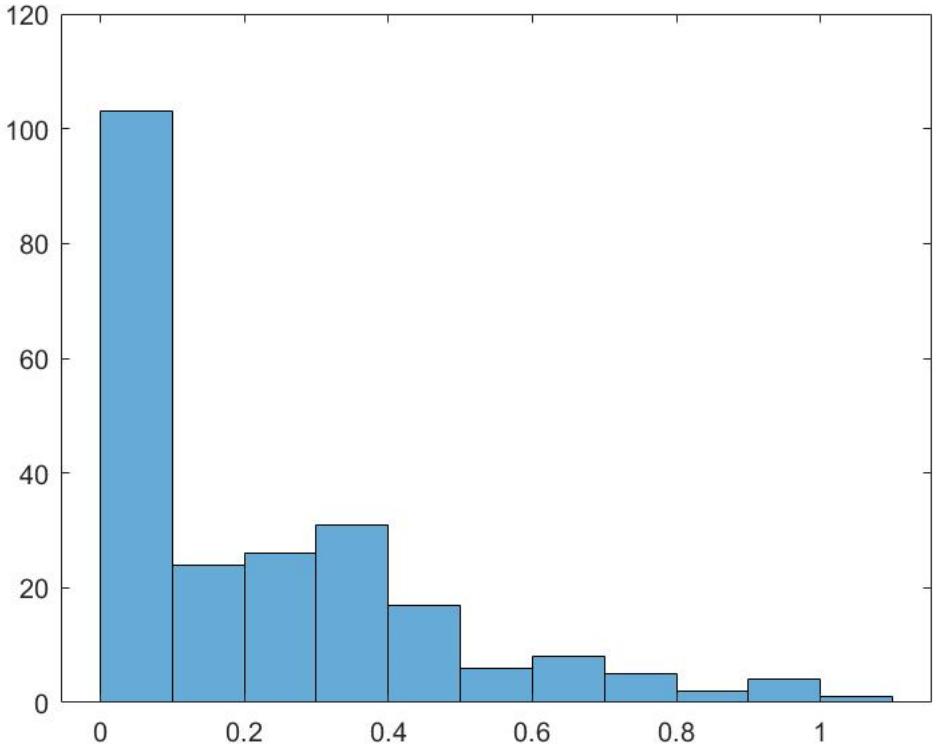

Figure 11: the histogram of errors in step path with Ld = 3

Here are statistics of errors:

Ld	mean	max	percentile 95	RMS
1	0.6813	2.4376	2.3417	1.0661
2	0.2864	1.1442	1.0688	0.4516
3	0.2148	1.013	0.7077	0.321

With the increasing of the Ld, path seem become smoother and more stable. At the same time, corner-cutting condition on bigger Ld is more obvious. The reason is we can see further in path tracking. Thus, some closer point in the path would be abandoned by the tractor.

Question: Double the speed. Should l d change?

Answer: NO. Speed has no impact on the turning ratio of the tractor. Thus, we don't need to change Ld to acquire same accuracy of following the same path.

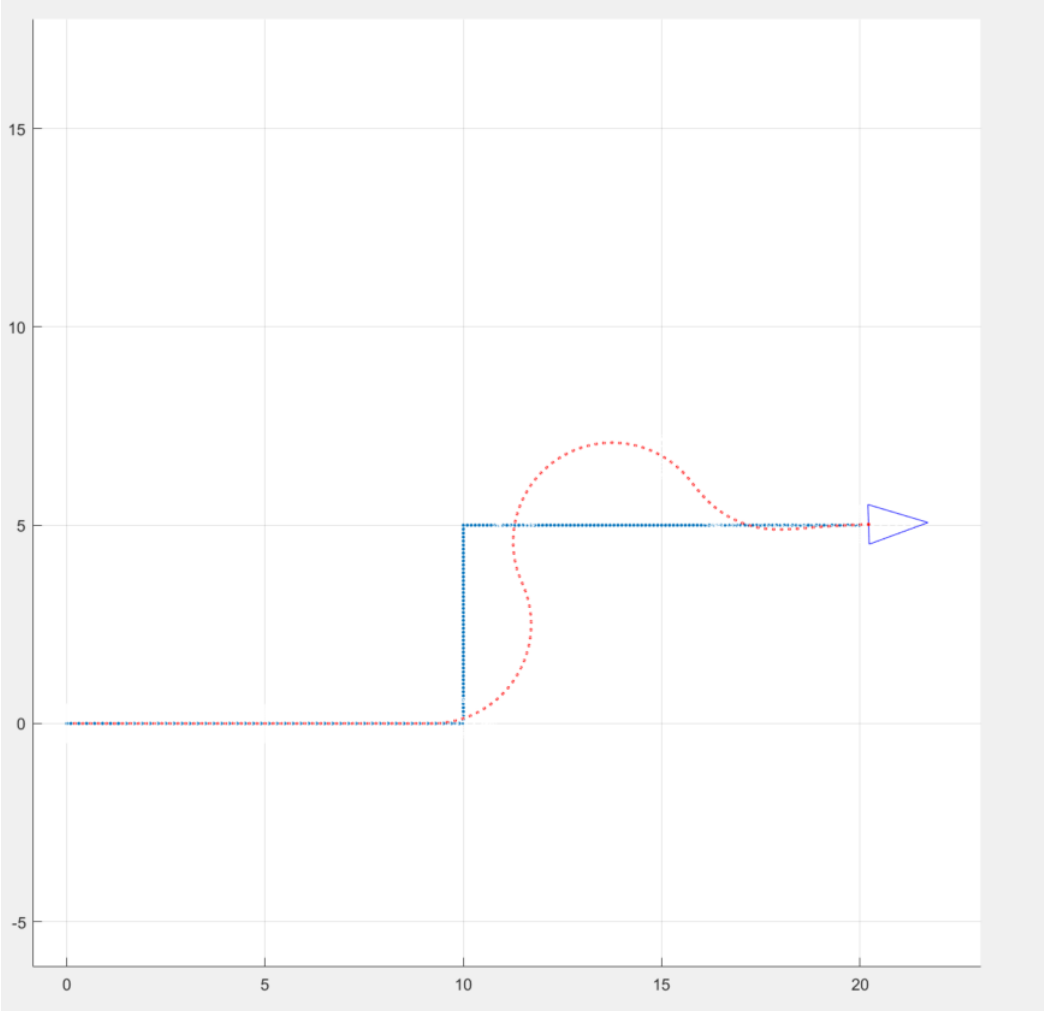

Figure 12: the step path with Ld = 1 and V_max = 2

Part 4: in this part, the base case is Ld = 3 and following a step path:

1. **With time lag:**

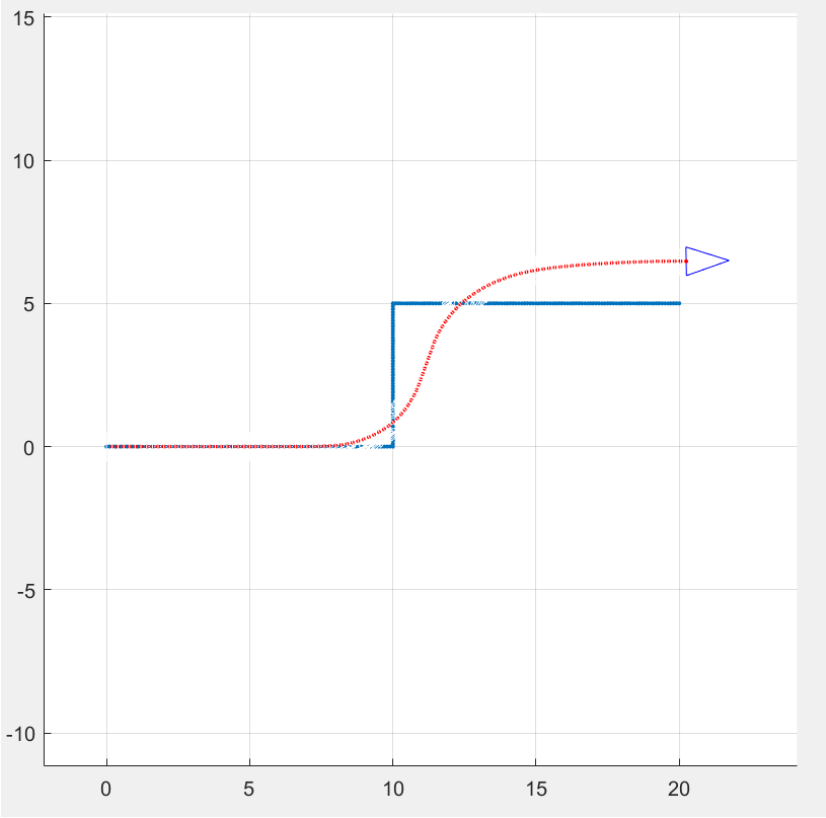

Figure 13: the step path with time delay

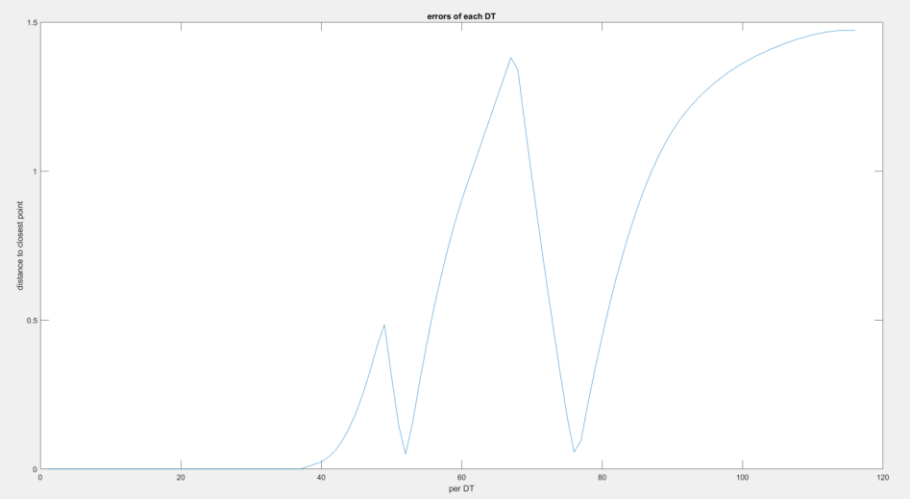

Figure 14: the step path error with time delay

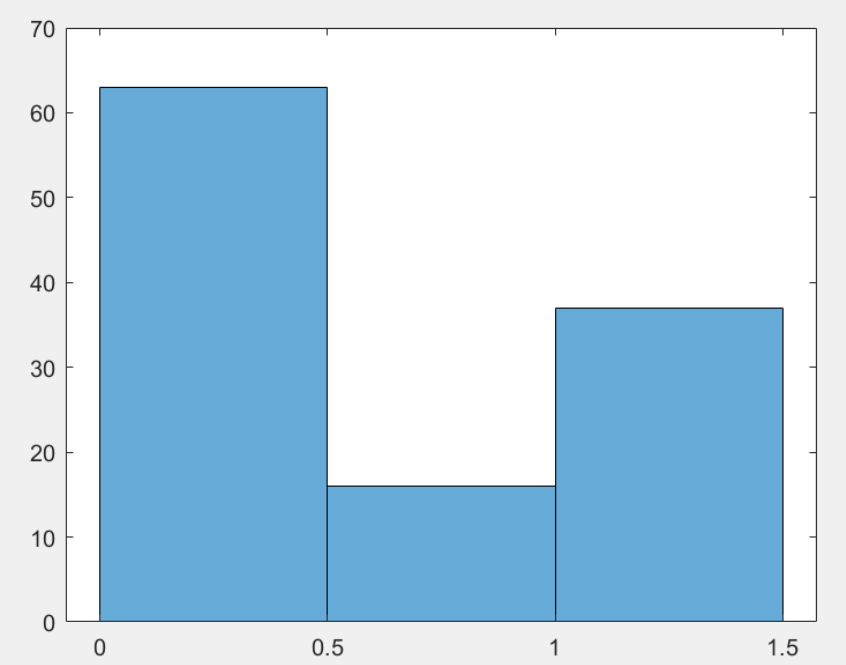

Figure 15: the histogram of errors with time delay

With time delay on steering and velocity, the tractor seems clumsier during turning. This is due to steering time delay. The tractor cannot reach the desired steering angle immediately. The path seems more smoother but the errors are larger.

2. **Double steering time lag:**

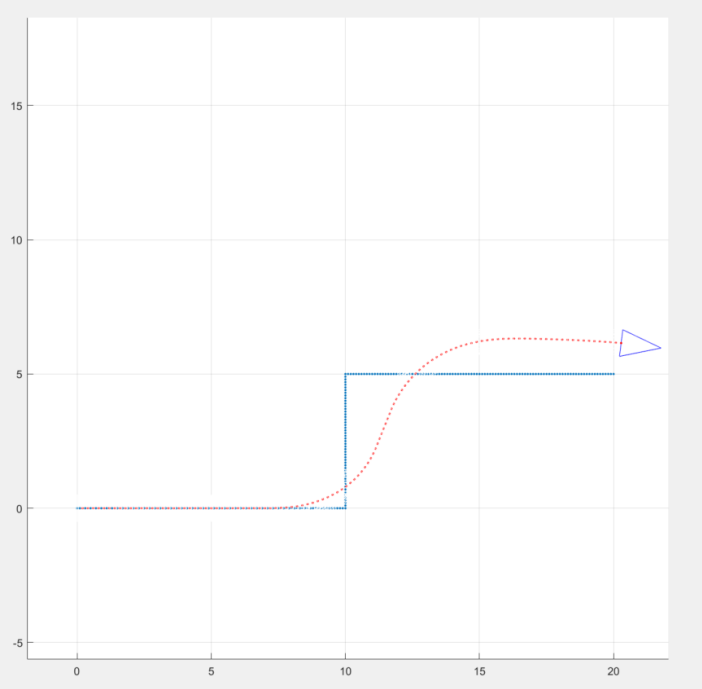

Figure 16: the step path with double time delay

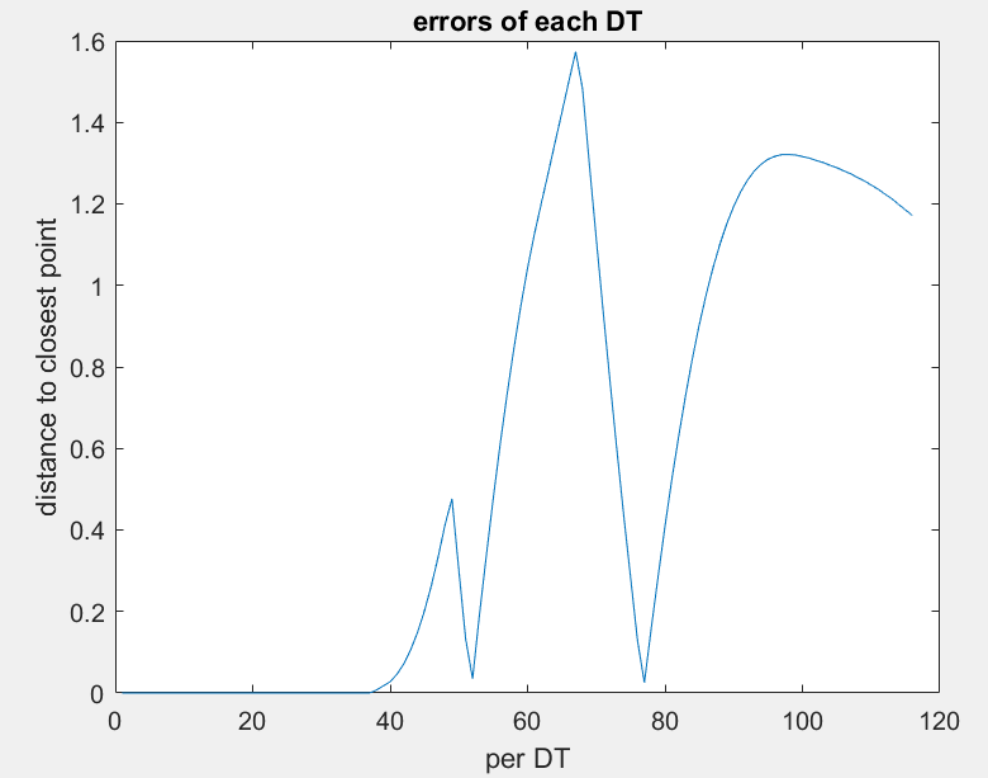

Figure 17: the step path error with double time delay

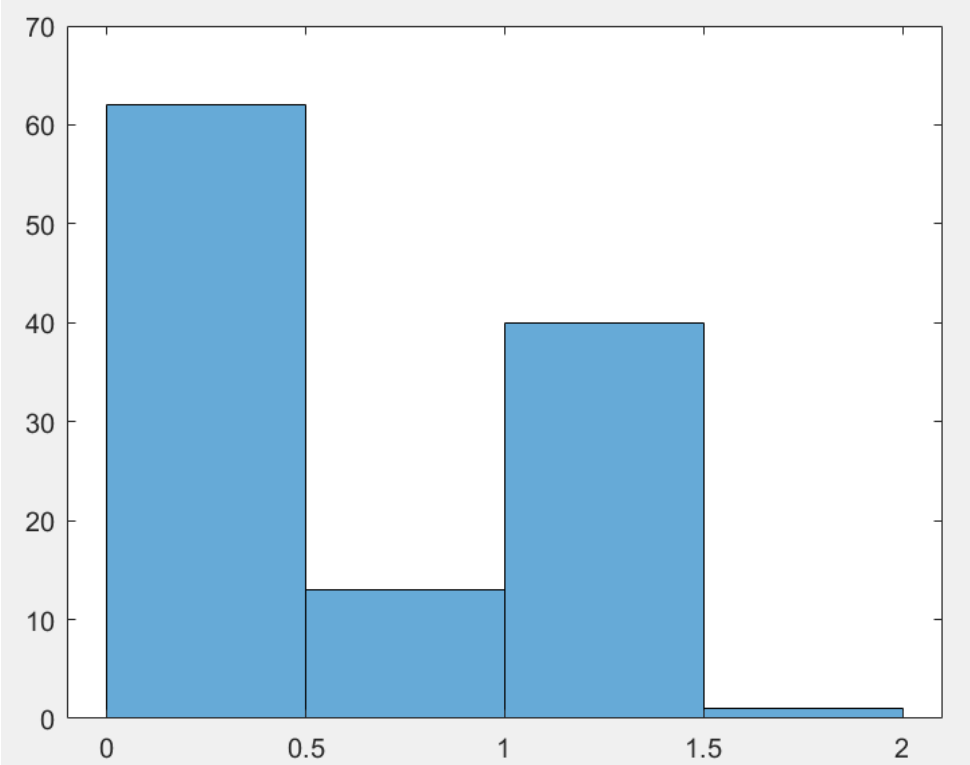

Figure 18: the histogram of errors with double time delay

When we double the steering angle time delay, the tractor supposed to be clumsier than case 1 discussed above. The path is smoother than case 1. At the same time, errors are larger when we double steering time delay.

3. **Tighten steering angle but no steering and velocity time delay:**

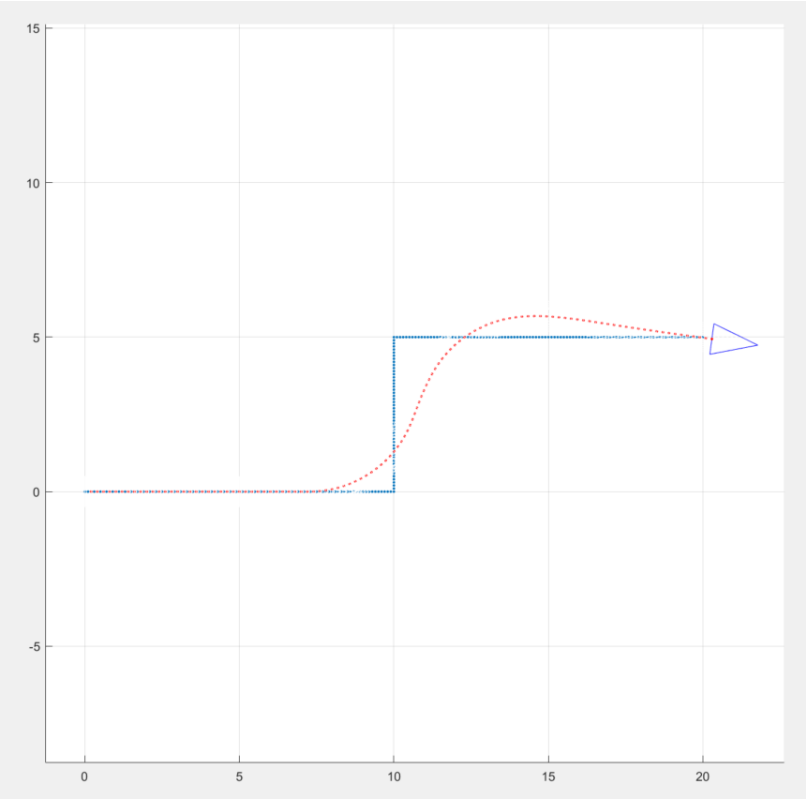

Figure 19: the step path with max steering angle = 35 degree

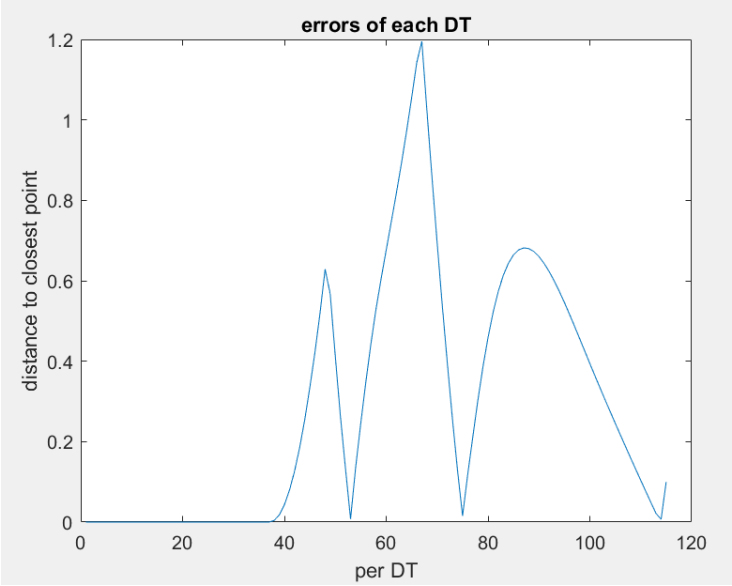

Figure 20: the step path error with max steering angle = 35 degree

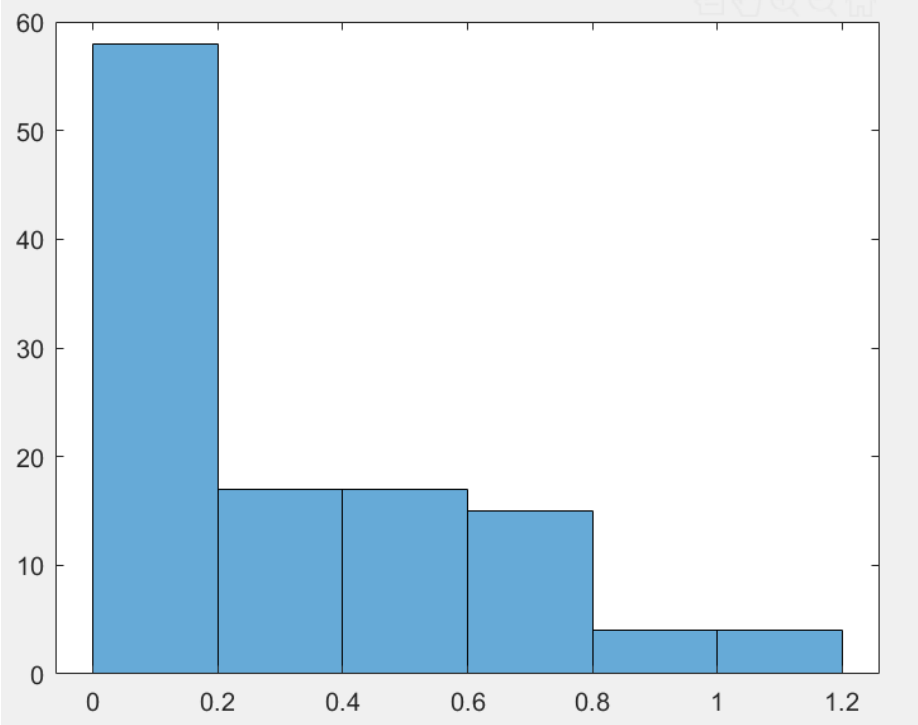

Figure 21: the histogram of errors with max steering angle = 35 degree

The effects of tightened steering angle constrain is letting the path looks smoother. The path looks like a tractor with steering time delay although the tractor can reach the desired angle immediately.

4. **Introduce skidding and slipping (delta 1 = 15-degree, delta 2 = 15-degree and s = 0.2):**

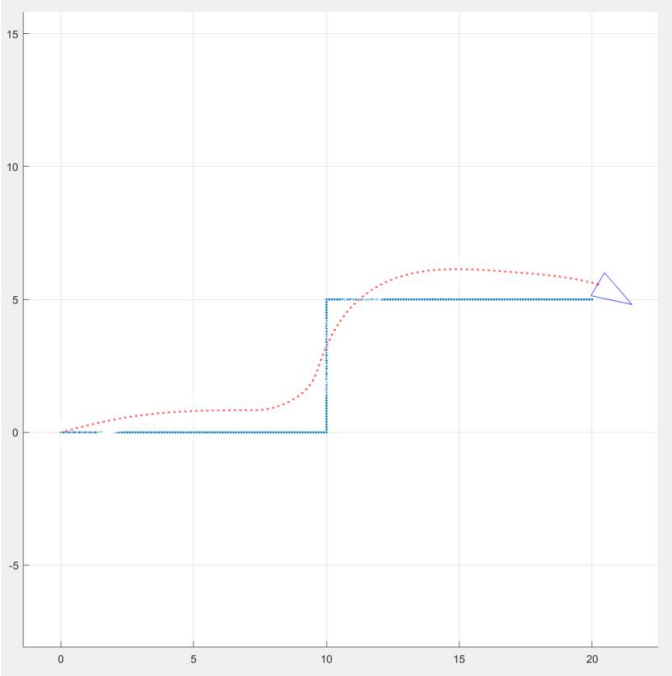

Figure 22: the step path with skidding and slipping

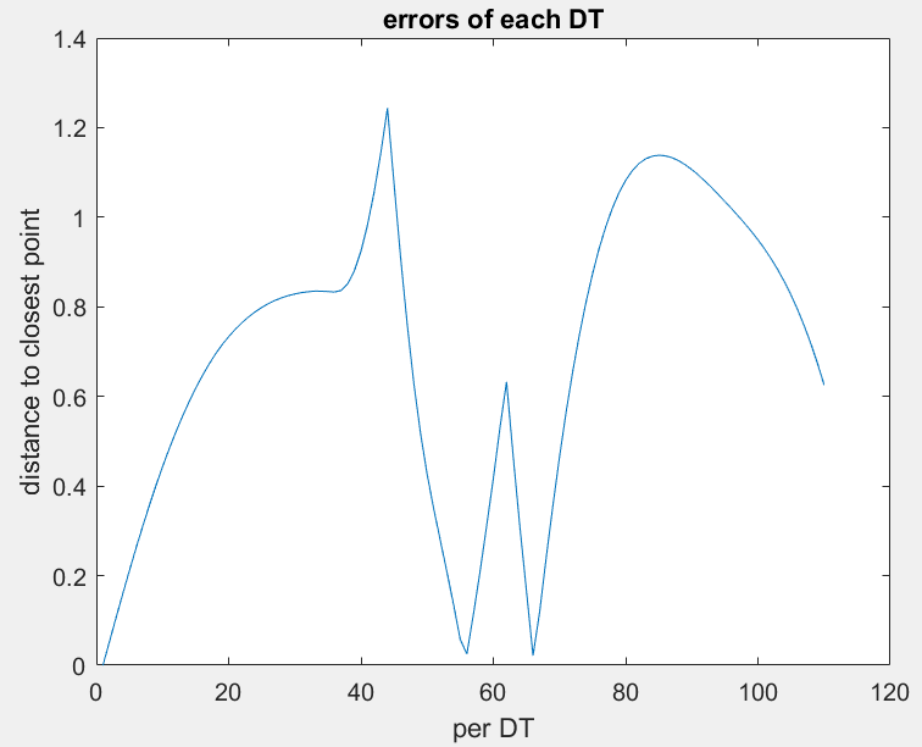

Figure 23: the step path error with skidding and slipping

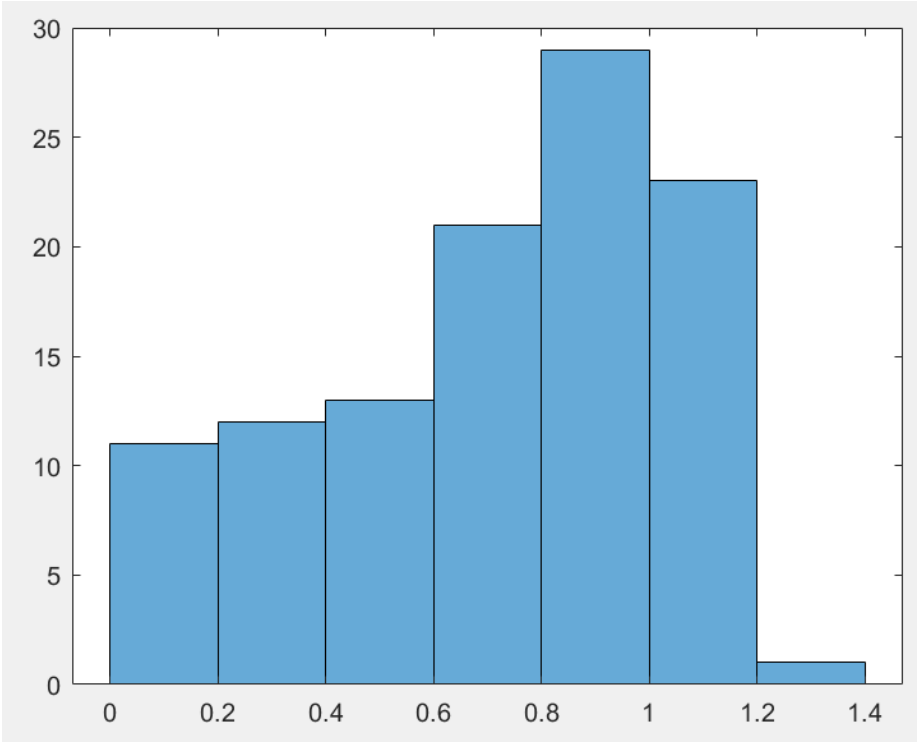

Figure 24: the histogram of errors with skidding and slipping

Skidding and slipping will cause a lot of errors while tracking path. We cannot generate straight lines and perfect circles. If we only care about the accuracy of tracking a path, slipping is not a bad factor. Slipping would only have impact on the speed of our tractor. Those noise are effects of skidding.

Errors of those 4 cases:

	mean	max	percentile 95	RMS
base case	0.2148	1.013	0.7077	0.321
case 1	0.5775	1.4727	1.461	0.8154
case 2	0.5796	1.5733	1.321	0.8088
case 3	0.2906	1.1954	0.8835	0.4258
case 4	0.703	1.2435	1.133	0.7753

For skidding and time delay factors, they all will have bad effects on tracking path. Slipping would make our tractor slower but with the same accuracy.