Thesis Outline

Trajectory Prediction for Auotonomous Vehicles

1. Introduction✓
2. Background✓
   1. Road modelling using Clothoids✓

* Why clothoids are used in road construction. ✓
  + 1. Clothoids✓
* First explain and motivate clothoids, use cases etc. ✓
* Define mathematical expressions of clothoids together with examples (2 different but similar examples, separate figure for both of them and another figure where both clothoids are observed). ✓
* Explain why it is useful for road construction but not for computation. ✓
  + 1. Clothoid Approximations using Arc Splines
* Briefly explain the motive of approximation. ✓
* Explain how it is possible to approximate with arcs (clothoids have increasing or decreasing curvature and it should be possible to approximate it with arcs)
* Step by step describe the approximation. Plot the Euclidian distance between approximation and clothoid. Plot the clothoid and arc approximated clothoid on the same figure. (Consider putting a plot where the centers of each arc is displayed similar to Ardam’s paper Figure 2.21 given below) ✓
  1. Waypoint Data
* What do we need for real time computations and its importance. Mention [Latitude,Longitude,Heading,Curvature] for each waypoint is used also mention that this is the waypoint definition. ✓
* In our case the data we have used only consisted of lat,lon pairs so I should mention about clothoid fitting method I have used. Should be referenced. (Hocam is it okay if I mention the method in this part since the method is used for both databases?) ✓
  + 1. OpenStreetMap
* Representation of GPS points and road type (data structure). ✓
* Sample data extraction in Germany. (One figure with satellite image background ) ✓
* Mention it is not very precise and try to find non-precise data example to display as figure. ✓
  + 1. HERE Maps
* Representation of GPS points and road type (data structure). ✓
* Sample data extraction in Germany. (One figure with satellite image background ) ✓
* Discuss it is more precise than OSM. ✓
  1. Beziér Curves
* Explain Beziér curves together with use cases (computer graphics, vehicle outer shell design etc.) ✓
* Give quintic Beziér mathematical expression. (derivative should not be necessary) ✓
* Discuss quintic Beziér curves properties (this type of curve can control their position, heading and curvature at both of its endpoints.) ✓
  1. Related Work:
* Mention offline map usage and offline maps in autonomous driving.(Data structure, source, credibility)
* Road modelling algorithms (B-splines, cubic spline etc, line interpolation)
* Trajectory planning algorithms (Bézier, Hybrid A\* etc.)
  1. Proposed methods and models:
* Mention shortages of current algorithms
* Arc-Spline approximation
* Bézier curve based and arc spline based trajectory generation
  1. Contribution:
* How we solve the shortages
* New method to represent a road
* Arc spline based trajectory generation
  1. Outline

1. Methodology

* Open up a standard main file of my own and I can summarize the overall procedure. SEEMS UNNECESSARY
  1. Road Segment Representation
* Give “road segment” definition. (it is the trajectory between two given waypoints, a segment can be an arc spline or a line type segment) ✓
* Mention that it is possible to represent the overall road with minimal data and low error. ✓
  + 1. Approximation (Both arc and line approximations are applied to ground truth assumption)
* Assume that we have clothoid representation for each segment also mention that clothoids can be approximated by arc splines. ✓
* Try to fit arc or line approximation based on predefined error metrics (mention acceptable levels of heading error, position error) ✓
* While fitting arc splines try different orders based on euiclidian error maximum and RMS value. (Provide Euclidian distance figure between approximation and ground truth over a sample segment, should I give it in the results section?) ✓
* PSEUDOCODE✓
  + 1. Combination (Consecutive same type segments are combined with respect to error parameters)
* Mention that it should be possible to concatenate same type segments and the logic behind it. (If there are 2 clothoids back to back, it may be possible to merge them into one). ✓
* Mention prerequisites for combination for clothoid segments (Curvature rates should be similar, segments cannot be concatenated if they have opposite signed curvature rates also curvature rate values should be close). ✓
* Mention prerequisites for combination for line segments (Starting heading value of the first segment should be close to the final heading of the last segment) ✓
* PSEUDOCODE ✓
  1. Other Lane Generation
* Discuss that it is possible to generate other lanes if the road width and road lane information is known for a particular “road segment”. ✓
* Explain the method for clothoid segments (it is possible to generate other lanes by changing the turning radius of arc segments). Give a figure so that the reader can observe. ✓
* (Provide Euclidian distance figure between generated lane and ground truth lane over a sample segment, should I give it in the results section?) ✓
* Explain the method for line segments (it is possible to generate other lanes by pushing the line segment perpendicular to heading of the line segment). Give a figure so that the reader can observe. ✓
* (Provide Euclidian distance figure between generated lane and ground truth lane over a sample segment, should I give it in the results section?) ✓
  1. Beziér Trajectory Generation
* Discuss why Beziér curves are useful for this thesis’ case (We will have the vehicle pose and final pose at hand therefore Beziér curves can generate smooth curves). ✓
* Discuss why should we have a number of candidate curves (For collision checking algorithms I need to have a variety of Beziér curves, this thesis does not focus on generating collision free Beziér curve). ✓
  + 1. Increasing the number of candidate curves
* Discuss method to have a variety of candidate curves (a few cites here) ✓
* Show the effect of changing the length of the initial and final tangents vectors. (Maybe provide a few figures here) ✓
* Show the effect of changing the length of the initial and final curvature vectors. (Maybe provide a few figures here) ✓
  1. Evaluation Metrics
     1. RMSE in spatial coordinates
* For a single line segment plot the RMS error by discretizing the road segment to 10 meter long subsegments. This means that for each 10 meter RMS value will be computed. ✓
* For a single clothoid segment plot the RMS error by discretizing the road segment to 10 meter long subsegments. This means that for each 10 meter RMS value will be computed. ✓
* For a long road (which has line and clothoid segments in it) plot the RMS error for each segment. (no subsegment here) ✓
* For a long road (which has line and clothoid segments in it) plot the RMS error and average curvature for each segment. Mention that it may be important to evaluate the method while considering the curvature. (no subsegment here) ✓
  + 1. Maximum error in spatial coordinates
* For a single line segment plot the maximum error by discretizing the road segment to 10 meter long subsegments. This means that for each 1 meter RMS value will be computed. ✓
* For a single clothoid segment plot the maximum error by discretizing the road segment to 10 meter long subsegments. This means that for each 1 meter RMS value will be computed. ✓
* For a long road (which has line and clothoid segments in it) plot the maximum error for each segment. (no subsegment here) ✓
* For a long road (which has line and clothoid segments in it) plot the maximum error and average curvature for each segment. Mention that it may be important to evaluate the method while considering the curvature. (no subsegment here) ✓

1. Results and Discussion
   1. Performance evaluation of the proposed method
   2. Comparison with existing methods (Don’t have many existing methods to compare at hand but I need to find while writing this part.)
2. Conclusion

