Passing Zone Report Two

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1 Project Description

Installing no-passing (double yellow) pavement markings to an unmarked roadway can reduce crashes by half. However, the criteria for no-passing zones are difficult to apply in a universal sense, but surveying every piece of road in a county, or even a state, takes resources, time, and money. The Porter County Department of Development and Storm Water Management has provided the following data: LiDAR surface DEM, roadway and ROW limits, accurate roadway survey, and no passing zones requirements. Elevation data can be projected onto roadway centerline data. An algorithm can be created to evaluate the three dimensional roadway data to determine the location of no-passing zones. Using the given data, as well as state and county road requirements from *A Policy Geometric Design of Highways and Streets* (2018, 7th edition), we will be determining the specifications per the roads in Indiana. Porter County will fly their surveying drone to obtain accurate elevation data of a few roadway segments to check the accuracy of the program output against the survey data.

In order to create such an algorithm, there are specific locations in Porter County that will be useful for testing the accuracy because of the more straight-forward, geographically diverse areas. Data provided is specific to three areas in the county. The first is a very straight road with elevation differences in terms of hills and valleys so that the algorithm can be tested on strictly vertical elevation differences. The second roadway has both hills and valleys as well as different directional curves. Lastly, as previously mentioned, passing zones can reduce crashes by half, so the last area is one of the most high-crash areas in the county. These high-trouble areas were located using a heat map based off of crashes in the county over the course of four years. The prime road we will be looking at is Meridian Road, one of the busiest roads in the county, with over 8,000 cars per day. Using data from these three to four areas, we want to determine which roads can have a no-passing zone, where the no-passing zone will start and end, and the confidence interval about the no-passing zone on that road.

2 Assessment

Those interested in the research analysis of no-passing zones include civil engineering, specifically from the transportation department, as well as the Porter County Department of Development and Storm Water Management. The public will benefit with an increase in safety from such analysis as well, as it has been previously stated that crashes can be reduced by half. Our research will be based on Porter County data, but the output of our specific project will be based on Indiana's roadway specifications and can therefore be modified to apply to other areas throughout the state. However, larger changes would need to be made for similar analysis to be conducted in other states since each state sets its own transportation and roadway laws.

Our research question is: based on the data from different sources from Porter County, can a program be made to determine the start and end of the no passing zones for horizontal and vertical criteria? Consider elevation data, right of way data, speed limits, driver height, reaction time, and rules for line placement. First focusing on elevation data, we can determine where no-passing zones should be based on visibility when ascending and descending through hills and valleys. Then, looking at right-of-way data, we can determine where no-passing zones should be based on visibility around curves. Our hypothesis is that we will be able to determine the start and end of the no-passing zones for horizontal and vertical criteria.

The success of our output can be weighed against survey data provided by Porter County's drone data. Such a comparison will be helpful in the early stages of our product development to see if the output is actually applicable. By comparing algorithm outputs to survey data, we can determine if it is possible to get an accurate output, or if it is necessary and safer to fly drones over the county roads.

3 Progress Update

Opening the files, visualizing what the data represents, and getting the data into a form that is useful for the algorithm has proved to be harder than expected. Because the LiDAR data is in .las files, an unfamiliar format based on previous programming knowledge or Datacamp lessons, it is more difficult than expected to find python packages and learn how to use them. Laspy is a python module that we have begun using to open .las files. For example, one of the functions opens the .las files in a list, so these lists can be transformed into a 2D numpy array to find road centers and evaluate locations of the elevations. Basic data exploration has been conducted, and the following next steps are for achieving the proof-of-concept traversal algorithm.

The next step is to rasterize the LiDAR data so that we can store it in a 2D array instead of a list of points. Each file is a 5000 by 5000 foot area, but there are only 11 million points in each file, so if the grid will have 1 square foot segments, some values will need to be filled in. One way to do this would be to assign some raster boxes a $\frac{dz}{dx}$ and a $\frac{dz}{dy}$ value. Then the values of the other boxes could be extrapolated from nearby boxes. A 3D numpy array would allow other values to be stored in each grid point. These values would include z for elevation, a boolean for whether or not it is the center of a road, a boolean for whether or not it is within right of way, a float for $\frac{dy}{dx}$ or someway to indicate the direction of the road at each center point, and maybe floats for $\frac{dz}{dx}$ and a $\frac{dz}{dy}$. Another possibility is using interpolation methods from the scipy package can be used to fill in the point field using the given LiDAR data points.

The algorithm will loop over the outer 2 dimensions of the numpy array, check if each point is the center of a road, and, if it is, run a testing algorithm to see if that point should be a passing zone or a no-passing zone. This will follow the direction indicator in both directions on the road for the required number of feet ahead of the car, and then evaluate the height of all boxes in between the car and the point up ahead. If the driver would be unable to see, the algorithm will mark the box as a no-passing zone, otherwise, it will be marked as a passing zone.

4 Updated Layered Development Schedule

1. Layer 1: Data Preparation and Preprocessing
   (a) Write code for accessing the data from the server using laspy (completed).
   (b) Write code for any necessary data cleaning (started).
   (c) Transform and combine data into a conveniently manageable form for Python, specifically storing points in a 2D array rather than a list of points to make data more useful for the traversal algorithm (started).
   (d) Do exploratory data analysis, such as finding how many points are in the point field as well as how close these points are to each other in order to determine what points this traversal algorithm can use (completed).
2. Layer 2: Proof-of-Concept
   (a) Using interpolation to create a fuller point field, create a traversal ("floating eyes") algorithm that will loop over the outer 2 dimensions of the numpy array to assess whether it is the center of the road (not started).
3. Layer 3: Minimum Viable Product

(a) Have the traversal algorithm consider elevation of a roadway to determine whether that piece of road should be a no-passing zone.

4. Layer 4: Desirable Target

    (a) Have the traversal algorithm consider right-of-way when relevant.

    (b) Have the traversal algorithm include a margin of error or confidence intervals in addition to a recommendation regarding passing status

5. Layer 5: High Target

    (a) Scale-up no-passing identification algorithm to larger portions of county dataset and other areas of Indiana.

    (b) Have the traversal algorithm consider adjustable speed limit data.

    (c) Allow industry constants to be adjusted, such as driver height, reaction time, and the particular rules for road line placement.

6. Layer 6: Extras

    (a) Identify roadway geometry (specifically centerlines and edgelines) from a LiDAR data set and (maybe) aerial photography.

    (b) Have the traversal algorithm check for visual obstructions within right-of-way.

We have neither given or received, nor have we tolerated others' use of authorized aid.

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