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Lane departure algorithm based on classification roadway type using DGPS/GIS

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Abstract

This paper suggestion detection algorithm when the vehicle depart lane boundary using GIS based on DGPS in the whole roadways. Lane segments obtained by GIS will be calculated its relative distance based on vehicle position. The lane segments are composed of consecutive straight lines and have a steady numerical error of design. In the curved section, its numerical error is bigger upon characteristics. Curve lane section, overlap area made of Bezier curve is calculated departure distance through continuity of driving characteristic and determines lane departure at curved roadways. To verify for proposed algorithm, lane departure test has driven 2-times of lane departure at each roadways. The result of compared between vision and departure alarm is showed driver its time within 0.1 seconds.

Keywords: *Lane departure, Intelligent function, Precision Localization, Bezier curvev, Classification roadway, DGPS/GIS*

1. Introduction

Fusion technology of multi-sensor for vehicle positioning has been developed at a rapid pace [1]over the past decades.[10] Accuracy positioning for vehicle is an important key that has improved performance of safety technology and help to safe driving correspond with environment. Intelligent vehicle which comprise electronic, electromechanical, and electromagnetic system is required to have robust safety controls and to provide precision repeatability functions. The one of intelligent function for vehicle is the driverless vehicle, which is capable of sensing its environment and navigating without human intervention.[1].

Warning line is defined by ISO 17361:2007. There are two types of warning line, one is earliest warning line and the other is latest warning line. The former is the innermost limit of the warning threshold and the last is the outermost limit of the warning threshold. Warning line is available to confirm start and end when a vehicle departs a lane. Location of actual warning line is rarely given to intelligent systems. Moon defined the position of the warning line with respect to the lane boundary which was obtained by GIS.[8] Jung have attracted integrating both functions of LKS+ACC system with embedded vision. [2] [5]

The map of information include road type is one of the key that make it possible to the problem of vision camera. [4] Although precision positioning and mapping techniques from the

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road shape have not yet been fully certified, but below studies have proceeded actively. Southall described a new system for estimating a road shape by combining information of a single camera and heading angle of the vehicle. [1] Moon has implemented lane departure warning (LDW) system based on the concept of warning line that depends on DGPS error. [9]

In this research, we can find the intersection point between the lane types (straight and curve) with computation result comparable to that of the correlation of gradient. It is essential to separate whether a curved lane or not and to calculate the gap before the lane departure happens. The line segment with curvature generates coordinate values of curved feature by Bezier curve using 3 points of referenced curve line. The lane departure algorithm should be also applied separately in the straight and curved lane for drivable path. The velocity of driving, its location, and segments of lane boundary and vehicle width are utillized detecting algorithm to reduce error. These requirements determine location of earliest warning line based on specification of positioning sensors and often involve estimated trajectory to determine quick and robust a warning signal. Above all, the algorithm can help to reduce arithmetic operation time, to make a decision and a warning.

2. Classification for the lane boundary segment

Lane boundary are on a paved lane to provide guidance and information to drivers. It used to minimize confusion and uncertainty for driving roadways. The boundary lane of segment has coordinate obtained from GIS, but it is difficult to maintain their marking as well as updating the lane boundary of segment. To maintain the boundary lane of segment, Kim suggested basis concept to update XY-coordinates as useful information for detecting safety drive. [3] The coordinate data for specific lane segments (straights, curves) is adapted to discriminate a departure status by calculating a gap with the vehicle positioning. A part of the evidence for improvement of a departure system is prepared to use the database of map obtained by GIS. The robust resulting of detection is started from seeking an intersection point between a straight lane and a curved lane.

It is necessary to analyze alignment radius of curvature for efficient intersection of the straight lanes. The characteristic of correlation coefficient which the gradient of continuous points can extract the intersection features by using boundary lane of the map tries to implement on GIS. In the case of Moon, which verified the intersection points for classification of lane types between straight and curved roadway. [7]

The intersection point for the longest curved/straight section is able to extract by computing of Eq.(1) ~(3) based on the demonstration of Moon for utilizing lane segments. [6]

By using extracting criterion with computation as defined in Eq.(1) ~ (3), the computation is to find a inflection point along path of the lane. To find inflection point, computation value is expressed the accumulated grade from start point to limited point. These accumulated grade of value is most reliably determined by 2-ways using first point and previous point.

The subscript f of Equation is the first point in the lane segments, the subscript p is a previous point based on the k-th point.

$$\beta^{k}_{(p,f)} = \left[2 \cdot \arctan \frac{du^{k}_{(p,f)}}{\sqrt{(dx^{k}_{(p,f)})^2 + (du^{k}_{(p,f)})^2 + (dx^{k}_{(p,f)})}} \right] \tag{1}$$

$$M^{k}_{(p,f)} = \frac{\sum_{k=1}^{n} \beta^{k}_{(p,f)}}{n} \tag{2}$$

$$C_{(p,f)}^{k} = \frac{\sum_{k=1}^{n} (\beta_{(p,f)}^{k} - M_{(p,f)}^{k})}{n} \tag{3}$$

2.1. Expression of line : straight segments

We can decide the comparative location of the vehicle and lane by making the extracted coordination value of boundary lane in the straight-lane segment like the above one as the linear equation.

The error of the recommended lane is declined by decision of the lane type, also it has advantage for the comparative decision in the quickly calculation when the high speed situation. Each extracted point of boundary line should be expressed and by reference center-lane based on two-roadways.

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$$L_{cn} = (X_{cn}, Y_{cn}) L_{cn+1} = (X_{cn+1}, Y_{cn+1}) \tag{4}$$

$$Pv_{i} = (Xv_{i}, Yv_{i}) Pv_{i+1} = (Xv_{i+1}, Yv_{i+1}) \tag{5}$$

$$f'(L_{cn}) \approx \frac{f(L_{cn-1}) - f(L_{cn})}{L_{cn-1} - L_{cn}} \tag{6}$$

Where P_{v1} is the current position, P_{v1+1} is next position. Position of lane will be executed N-times, but the location of vehicle will performed in accordance with i - time of DGPS time synchronization.

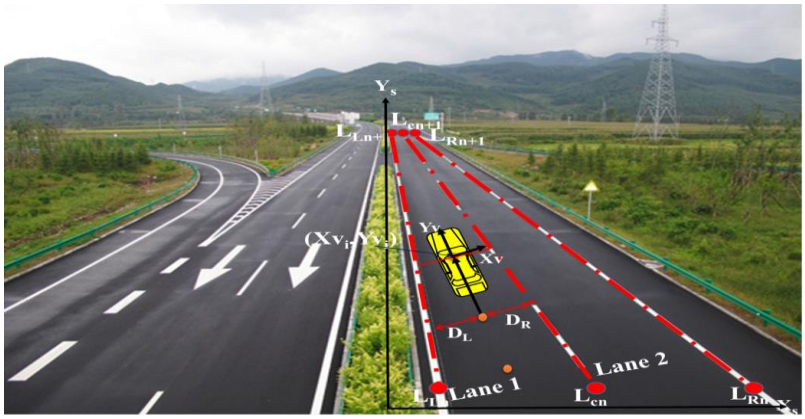

Figure 1. Straight lane segment and update of GIS line

To classify a straight segment requires simply calculating each boundary lane by connected point at 7-meter intervals, as in Figure. 1. When the points was determined continuously by two points of boundary lane, $L_{cn'}$, $f(L_{cn})$, and their derivatives are determined using Eq.(6).

A vehicle localization of coordinate data is refined in the local reference a (X_v, Y_v). This position are calculate with lane boundaries segments above defined to measure their relative gaps. The gap is shown in the D^R of the right boundary lane, D^L of the left boundary lane.

2.2. Expression of line : curvature segments

One important factor in design of a curved road is the radius of curvature based on standard speed. Points extracted from line data of GIS can be straightened from which there is a curved lane segment, but they has tended to require many points to reduce distance error. Thus, we demonstrated here a curved lane from a quadratic Bezier curve. To show an inactively curved road Figure. 1 that denotes a fitting line based on a quadratic Bezier curve that combines two consequent of lines by linking points of line. This is used to have feature that affect curved shape by controlling vertex more than an order of curve equation.[10]

Hence, the control point PN guarantees the expression of the curve lines. Resulting information of curve line can be obtained with the second order Bezier curve equation, where B(N) of position of N step has setup interval 0.01 steps between 0 to 1 second, and P0, P1, and P2 refer to start, control, and end point, respectively, finding a dividing point for line segment P0,P1 in t-seconds.

3. Result and experiment

We demonstrated false alarm test to verify algorithms. Despite of different the habits of the traveling vehicle, the result of straight traveling shows location at the safety zone within an alternate long and short dashed line with red color as shown in Figure 8. This results means the algorithm set a reliable operation in performance. Definition the criterion of boundary lines, which one of left side sets 0 cm and the other side, is 139 cm as limited distance with the earliest warning line.

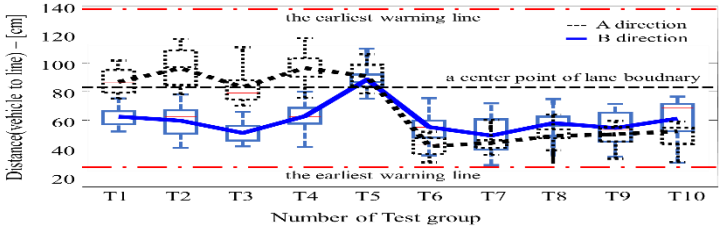

Figure 2. Distance gap from lane when vehicle driving in a straight road

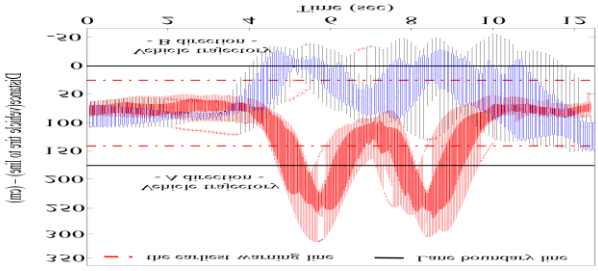

Figure 3. Warning of lane detection with Vehicle trajectory

4. Conclusion

This article present a lane departure algorithm using DGPS sensor based on lane information obtained from GIS. As like previously research, a dynamic efficiency test is shown that positioning level is under 20 cm by transmitting RTCM message in the WAVE communication. Furthermore, detecting algorithm has implemented each environment condition as straight and curved roadway, which has utilized compartmental area through classification method of roadway type and finding the intersection points. In the straight section, vehicle lateral speed and direction angle of vehicle has offered help to compute distance between vehicle tire and lane boundaries. Lane elements as a reference line that are linked first point Po and the intersection point Pn for linearized line has fitted lane boundary, which has matched each lane boundary of segment. In the curved section, lane segments updated by Bezier curve arithmetic has overlapped that area to share. The updated lane segments has created more 10-times by connecting 3-points segments. These segments are able to reduce error through comparison with real lane segments. There is a possibility to analysis for characteristic vehicle travelling based on lane boundary using positioning data.

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