A Novel Neural Network based Voting Approach for Road Detection via Image Entropy and Color Filtering

Nasrabadi Abbas\(^1\) and Vaezi Mahdi\(^2\)

\(^1\)Mechatronics Engineering Department, Computer and Electrical Engineering Faculty, Hakim Sabzevari University, Sabzevar, Iran
\(^2\)Science and Research Branch of Azad University, Computer and Mechatronics Faculty, Tehran, Iran; Abbas.nasrabadi.it@gmail.com

Abstract:

**Background:** The dramatic increase in the traffic needs effective management that leads to the creation of intelligent transportation systems (ITS) or smart roads. **Method:** In this paper, a novel and quickly executable neural networks based method is presented to decide the configuration of an adaptive filter and choose among many possible segments of image. **Findings:** The trained network can be put in practice easily, a number of test image are presented to the software, and the program calculates the multiplication of each scene's entropy and histogram average and based on that the trained radial basis network predicts the suitable filtering parameter. Result show the outcome of the network trial on three examples. It's obviously because that the current input has values which are relatively close to the values put at the training stage. **Applications/Improvements:** A lot of research can be committed about enhanced filtering and masking ideas. A human operator is needed to approve the output's readiness to be segmented.

**Keywords:** Color Filtering, Image Entropy, Machine Vision, Neural Networks, Online Road Detection

1. Introduction

Despite the complexity and diversity of the online road detection problem and too many failed attempts and unsuccessful efforts still the excessive urgency of improved traffic safety and autonomous vehicles development obliges this objective to be accomplished. After reviewing the previous jobs we present an innovative neural networks based method to configure the filter applied at each frame and decide the thresholds of filtering the image to be prepared for the segmentation operation through omitting the unwanted objects presented on the image.

Currently, the rapid increase of traffic and its consequences of mismanagement demands higher level of traffic safety and security\(^1\). A health issue of the driving person may mean a disaster for the person and other people's lives and property and some safety systems are required to handle the situation. Also the autonomous vehicles and robots are in shortage of effective path finding and guidance systems\(^2\). Therefore monitoring the safety system especially focusing on vehicle's navigation system is indeed needed\(^3\).

The heart of such system is of course the road path detection system, various sensors and data dispatching-receiving subsystems might be necessary for this part. But while stuff like GPS and radars might not always be available or reliable; a vision sensor (or camera) seems to be the major necessity here and therefore the computer vision algorithms and hardware\(^4\) become the necessity.

For the past two decades, significant efforts have been made to develop automated road detection subsystems\(^4-10\).
While most of the early works were concentrated on indicating a fine paved and structured road which is ready to separate at a standard image segmentation sequence and various methods like stereo vision\textsuperscript{11-14}, colored and dyed markers\textsuperscript{15}, Hough transforms\textsuperscript{16,17}, steering filters\textsuperscript{18}, contour models\textsuperscript{19} and other standard machine vision methods have been applied while still little works have been committed on the purpose of detecting various road types from standards highways to rural not paved paths and these methods despite their voluminous processing calculations may quickly fail encountering these unpredictable conditions.

The idea is essentially about to make a good guess about which image segment is to be assumed as a drivable path. A road scene may contain various kinds of vertical, horizontal and other shapes like buildings, walls, sidewalks, clouds, jet streams of airplanes, sky, other vehicles, road signs and else which can all come in a very vast range of shapes, colors and textures plus the various kinds of road paving and lanes there for an elaborated set of rules to categorize and classify image segments is needed to decide about the probability of the right choice amongst.

One of the most reliable features of such segment is its geometrical characteristics as is debated and utilized in\textsuperscript{20} but certainly one feature alone can’t be trusted with the task since, for example, a wall can come with a very similar form with a road and easily mistaken just as implies for other similar jobs.

One another likely road feature which has been attended to be detected and utilized as the standard road detection tool is the road lanes as is mentioned in\textsuperscript{21,22,23} which may only exist in standard structured roads. Other feature used is the estimated location of road’s vanishing point like in\textsuperscript{24,25} which can be affected by weather and lighting conditions and is not a very suitable ratio to identify the road. Another approaches like texture classification are also noted\textsuperscript{26,27,28} and put into practice but still this properties alone can’t be categorized as any more trustworthy standard since roads can come in a variety of pave and also there are other objects with similar texture structures like walls presented at images.

There had been better ideas attended though, in\textsuperscript{29} supervised training of convolutional neural network based on fractural texture analysis segmentation is presented which despite the excessive amount of required computations is still a single feature based method and also needs a supervision at both raining and testing stages with no reliable results. And at\textsuperscript{30} the same network is trained with respect to the image’s edges and colors which still comes with no general solutions since the method only proves useful on analyzing the similar scenes to the training image set.

Here at this current article with respect to the previous efforts a novel method is devised. An entropy based color filtering method is developed and a neural network will be trained with respect to the various extractable features of the image with a true-false vector as the desirability flag. There for after trained and designed the matrix of the neural network can be used at online conditions to judge each grabbed frame and find the road segment.

2. Current Method

The main idea is learnt from the previous jobs actually. All of them use elaborated algorithms to segment and detect while despite the complicated computations still often fail. But what has been the cause of failures and inconvenient? It’s of course the essential need of the nature, the adaptation. The majority of the computer vision algorithms are based upon predefined methods and mathematics while the major and yet forgotten advantages of the nature is adaptation and perfection. Obviously it’s not possible to established such a comprehensive formula which can cover all the happening configurations of illuminations, objects, textures, weather conditions etc. now in order to train a radial-basis network for this purpose there are two matrixes needed as for the given input and target output. Through analyzing many frames of different roads and conditions the immediate need of any path detection method is a suitable filter to indicate the right color, edge and texture of the road while all the previous works delivers us to this conclusion that a non-adaptive mask or algorithm won’t do. There are some mutual features of all routs. They have specific textures and colors while the edges might not be always distinguishable because of many elements. The important parameters of segments can be learned from the previous works, the key features indicating the existence of a road can be described as:

a. Edges: Long directed edges can be a reliable sign of possible road existence. So regions with a large ration between the horizontal wideness and vertical edges are candidate to be probable paths.

b. Texture: There are only several common types of road paves utilized around the word, It’s usually either pitch asphalts, flagstone pavement or trampled soil.
c. Color: Roads based on the applied surface covers mentioned above come in few choices of dye, its specters of black and white.

An algorithm for a supervised method of analyzing and training is developed upon the average entropy of road scenes for several kinds of roads at different sighting and lighting-weather conditions. A variable mask is proposed as initial guess to filter the color and texture of the images, the result of filtering is shown to the human operator and if he can indicate the path in the resulted binary image the presumed values of mask are approved and saved for the current entropy and if not a repeat sequence circles among variations of mask of more than the operator confirms one, though the data generating stage might prove to be time consuming but it's a procedure which is committed only once. So the input vector is a set of entropies and the output are suitable masks for the particular entropy. However entropy alone can't be a totally reliable matter and different imaging situations may result in close entropy values another ratio is measured, the average amount of the histogram. The two vectors merged as one input vector for the network training stage. Despite that the data generating phase proposed here is supervised and difficult but an arranged network's matrixes can be put at the embedded hardware on the vehicle easily and can act instantly about each frame's segments. The only requested preprocessing stages are the usual vision operations of enhancing and segmenting which are common among all similar systems. And finally bout the filtering method, the filtering uses a calculated multiplication of average entropy and histogram as the initial value. Then this factor is used in two levels of processing the colored RGB image, at first only the pixels which has the color portions of R, G and B matrixes not varying more than this given value are to be picked and from among those the only ones which have lesser and more absolute values of a multiplication of this given factor are chosen. This filtering strategy is established over studying and concluding the previously attempted approaches. The result of the operation on each sample scene is shown to the human operator. The operator should confirm the visibility of the road section at the binary image output. If the output is approved then the current masking value is saved as the appropriate one for the current entropy and histogram situations and if not it varies again until the operator chooses the best visual properties. As for the result two vectors are prepared. The input as described is a ration of image’s entropy and histogram and the output vector shows the suitable mask value for each input candidate. Of course like any neural networks based strategy more training examples will result in better trained networks with more comprehensive reactions.

In order to improve the efficiency of the operation some image enhancing steps are also taken like noise reduction and edge enhancement. After the trained network decides for the suitable values of the filtering mask a clearly distinguishable binary map should be created which is ready for further common vision operations. Closing, hole filling and some other conventional stages are committed to remove the unwanted segments and increase the ability to indicate the useful one which will become often the largest and only remaining label on the matrix. As like all neural networks based methods applied for many kinds of scientific and engineering problems as more of the training data gets presented for the network a better performance can be expected. Well one can’t ask for more with respect to the fact that the brain itself learns for each new conditions and untrained or slowly adapting person can’t perform much better than an untrained artificial neural network.

Figure 1 shows the filtering and training data generation sequences for several examples, as explained at each step software asks the operator about the reliability of the output image to be suitable for further vision operations. 

Figure 1- A set of sample images which are filtered using artificial neural network.

Figure 3- Shows the system approves itself to be very effective at this image, it’s obviously because that the current input has values which are relatively close to the values put at the training stage.

3. Results

The trained network can be put in practice easily, a number of test image are presented to the software, and the program calculates the multiplication of each scene’s entropy and histogram average and based on that the trained radial basis network predicts the suitable filtering parameter. Figures 3-5 show the outcome of the network trial on three examples. It’s obviously because that the current input has values which are relatively close to the values put at the training stage.
like shadows or reflections and that's because of the color conditions assumed to be applied at the filtering process. Of course, this feature stands as long as the condition has been anticipated at the training phase.

Figure 5 shows an unforeseen condition of histogram and entropy is ut to practice here as there are not similar scenes presented at Figure 2, but the program could still prove itself to be effective. However, one can't expect that the same network might show the equal degree of efficiency at all unforeseen conditions. Better results can be generated through presenting a more thorough set of training data.

4. Future Expansions

The proposed method however is at its conventional stages, first of all, one may speculate on designing better filtering strategies which can be done with virtually infinite sorts. In other words, a lot of research can be committed about enhanced filtering and masking ideas. Second, a human operator is needed to approve the output's readiness to be segmented and labeled while a person may become

Figure 1. A set of sample images which are filtered using a mask which adapts at each stage, the user shall choose the most appropriate image so the software can record the related filtering parameter as the most fit one for the current entropy and histogram situations.

Figure 2. At this work a set of 25 examples were utilized to choose the training data.

Figure 3. The system approves itself to be very effective at this image.

Figure 4. Another example, the interesting feature of this work can be observed here.

Figure 5. An unforeseen condition of histogram and entropy is ut to practice here as there are not similar scenes presented at Figure 2, but the program could still prove itself to be effective.
exhausted and even make mistakes especially when a plenty of training samples are presented, a more sophisticated software may be considered to replace the human operator. The software is required only to determine the existence of true segments but that’s the sole goal of the current job.

And as more ideas may emerge, one curious researcher may want to take further steps toward the next stages which are expected to be executed after this. Those are the erosion of unwanted regions, enhancement of the target areas and improvement of decision making strategy when more than one possible segments are seen at the end of the processes.

5. References

1. Kabor G, Boker J, Palkovis L. Lane-Departure Detection and Control System for Commercial Vehicles. International Conference on Intelligent Vehicles. 1998 Aug; 8(4):271-85.
2. Rasmussen Christopher. Road Detection and tracking for Autonomous Mobile Robots. Gaithersburg: Intelligent systems division, national institute of standards and technology. 2002 Nov; 13(5):24-46.
3. Chang T-H, Lin C-H, Hsu C-S, Wu Y-J. A Vision-Based Vehicle Behavior Monitoring and Warning System. Proceedings 2003 IEEE Intelligent Transportation Systems. 2003; 1:448-53.
4. Geman D, Jedynak B. Detection of roads in satellite images. International Geo-science and Remote Sensing Symposium. 1991 Nov; 32(1):94-105.
5. Geman D, Jedynak B. An active testing model for tracking roads in satellite images. IEEE Transaction of Pattern Analysis and Machine Intelligent. 1996 Apr; 18(1):1-14.
6. Gunst M, Han C, Lemmens M, Munster RV. Automatic extraction of road from spot images. Oxford: ISPRS/OEPE Joint Workshop,UK. 1991 Jul; 21(5):214-23.
7. Maruyama H. Present state of the map making by satellite image. Photograph Measure and Remote Sensing journal. 1993 Oct; 20(9):112-22.
8. Mukherjee A, Parui S, Chaudhuri B, Krishnan R. An efficient algorithm for detection of road-likestructures in satellite images. Proceedings of the 13th International Conference on Pattern Recognition. 1996; 3:875-79.
9. Rianto Y, Talguk K, Shozo K. Automatic road detection from the satellite image using zero-crossing algorithms. Tokai University. 1993; 25(2):2-15.
10. Rianto Y, Talguk K, Shozo K. Automatic road detection from the satellite image using zero-crossing. IEICE Spring Conference. 1994 May; 27(9):214-27.
11. Priyan S, Srivatsa SK. Detection of Duplicate Region and Hybrid Non-Local Means Filtering for Denoising with Quantization Matrix Estimation for JPEG Error Analysis. Indian Journal of Science and Technology. 2015 October; 8(28):323-31.
12. Rianto Y, Talguk K, Shozo K. Detection of roads from satellite images using optimal search. International Journal of Pattern Recognition and Artificial Intelligence. 2000; 14(8):1009-23.
13. McCall JC, Trivedi MM. Video based lane estimation and tracking for driver assistance. IEEE Transaction of Intelligent Transportation Systems. 2006; 7(1):20-37.
14. Bertozzi M, Broggi A Gold. A parallel real-time stereo vision system for generic obstacle and lane detection. IEEE Transactions on Image Processing. 1998; 7(1):62-81.
15. Sun T-Y, Chan V, Tsai S-J. HIS Color model based lane-marking detection. Toronto: IEEE Intelligent Transportation Systems Conference. ITSC’06, Ont. 2006; p. 1168-72.
16. Montazeri-GhM, Mahmooodi-KM. Development a new power management strategy for power split hybrid electric vehicles. Transportation Research Part D: Transport and Environment. 2015 June; 37:79-96.
17. Yu B, Jain AK. Lane boundary detection using a multi-resolution Hough transform. Santa Barbara: Proceedings International Conference on Image Processing, CA. 1997; p. 748-51.
18. Freeman WT, Adelson EH. The design and use of steerable filters. IEEE Transactions on Pattern Analysis Machine Intelligence. 1991; 31(9):891-906.
19. Wang Y, Teoh EK, Shen D. Lane detection and tracking using b-snake. Image and Vision Computing Journal. 2004; 22(4):269-80.
20. Geman D, Jedynak B. An active testing model for tracking roads in satellite images. IEEE Transaction of Pattern Analysis and Machine Intelligent. 1996; 18(1):1-14.
21. Samadzadegan F, Sarafraz A, Tabibi M. Automatic lane detection in image sequences for vision based navigation purpose. Tehran: University of Tehran. 2013; p. 1-6.
22. Ganokratanaa T, Ketcham M, Sathienpong S. Real time lane detection for driving systems using edge detection and Hough transforms. Bangkok: 3rd International Conference on Digital Information and Communication Technology, ITM. 2013; p. 104-109.
23. Montazeri-GhM, Mahmooodi-KM. An optimal energy management development for various configuration of plug-in and hybrid electric vehicle. Journal of Central South University. 2015 May; 22(5):1737-1747.
24. Kong H, Audibert J-Y, Ponce J. General Road Detection From a Single Image. IEEE Transactions on Image Processing. 2010 Aug; 19(8):2211-220.
25. Kong H, Audibert J-Y, Ponce J. Vanishing point detection for road detection. Miami: IEEE Conference on Computer Vision and Pattern Recognition, CVPR’09, FL. 2009; p. 96-103.
26. Zhang J, Hans-Hellmut N. Texture-based segmentation of road images. Proceedings of the Intelligent Vehicles. 1994; p. 260-65.
27. Graovac S, Goma A. Detection of Road Image Borders Based on Texture Classification. International Journal of Advanced Robotic Systems. 2012; p. 1-12.
28. Vaishnavi D, Subashini TS. Image Tamper Detection Based on Edge Image and Chaotic Arnold Map. Indian Journal of Science and Technology. 2015 March; 8(6):234-241.
29. Nair V, Parthasarathy N. Supervised Learning Methods for Vision Based Road Detection. University of Stanford: USA. 2014; p. 112-50.
30. Alvarez JM, Gevers T, Cun YL, Lopez AM. Road Scene Segmentation from a Single Image. Berlin Heidelberg: Computer Vision-ECCV’12, Springer-Verlag. 2012; p. 376-89.