# THREE LINE SCANER IMAGERY AND ON-STREET PACKED VEHICLE DETECTION


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**ABSTRACT:**

In the study, we proposed new algorithm of stopped vehicle detection using Three Line Scanner Imagery or TLS briefly. A framework of our study consists of three stages: Pre-processing , Moving/Stopping Vehicle Discrimination and Parking/Signals Waiting Vehicle Classification respectively. The Pre-Processing Step is fundamental information preparation such as vehicle-likely regions etc from Forward/ Nadir images. In Stopped/ Moving Vehicle Detection algorithms, stopped vehicles are detected by grouping vehicle candidates and verifying candidates as detected stopped vehicle as 3d objects using the Stereoscopic measurement on forward/nadir TLS images while moving vehicles are extracted by using our new 'expansion proceed' method to generate moving vehicle candidate and validating candidates as detected vehicles using spatial-temporal techniques on forward/nadir TLS images. In our last algorithm, Parking/ Idling Vehicle Classification, on-street parked vehicle is detected by measuring the distance from the edge of the road to the side of stopped. Parked vehicle is agreed with this distance thresholding defined by a ground observation. The algorithm is typically useful in cities. Finally, the promising results are derived and listed.


## 1. INTRODUCTION

Traffic congestions in urban area worsen quickly. On-street vehicle statistics collection is very crucial. A practical and effective approach is the vehicle observation by Remote Sensing techniques because image from remote sensor distributes a top-view and wide-area observation compared with ground-based sensors as Video Camera etc and now, remote sensing image is higher resolution. Those images are able to distribute their merit for object identification.

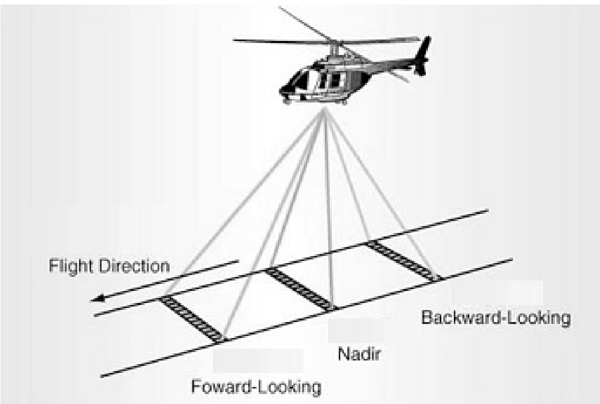


Figure 1 Three Line Scanner

Recently, Three Line Scanner, TLS, novel airborne line-imaging sensor, is available. Three Line Scanner imaging systems consist of three parallel one-dimensional CCD cameras mounted on the imaging plane with a Stabilizer for shaking reduction during imaging flight. It obtains seamless ultrahigh-resolution images, with three viewing directions (forward, nadir, backward direction) simultaneously with RTK-GPS and INS. By seamless imaging capability along the road, TLS image is very suitable to detect linear feature ground object such as road etc. Therefore, in our contribution, by using TLS, on-street vehicle monitoring has been developed.

The merit of TLS is not only distributing 3 dimensional imaging but also distributing positioning of Sensor during imaging by INS/GPS mounted with sensor. Moreover, due to TLS image with centimetre order resolution, the small object such as car pillar is identified. Because of tropical liner seamless image, it is simple to detect ground linear objects such as road etc from the image. Therefore, this image is suitable with vehicle detection from TLS imagery

## 2. RELATED RESEARCHES

At the present, there is not much review on vehicle detection using aerial image. All of them are categorized into a variety of aspects such types of sensors, target vehicle types or types of measurement etc. In terms of data, almost all existing methods apply frame aerial images. Several authors have presented approaches that utilize implicit vehicle models [1] [8]. Many successful approaches use explicit models [3] [4]. Although both approaches have merits and weak points, the implicit model approach, which is based on radiometry, is limited due to local radiometric disturbances and uncertainties about the accuracy of data training, which varies with illumination, viewpoint, and the types of objects in the training data [4]. Therefore, the explicit model is possibly more robust than the implicit model.
However, there are neither any approaches that mentioned stopped/ moving vehicle detection in one system by using one type of data nor parked/ traffic signals waiting vehicle discrimination

Please remind the organization of the paper. Chapter 2 reviews existing work of vehicle detection by using aerial image and their weak points. The overall structure of our contribution is mentioned in chapter 3. Chapter 4 and Chapter 5 describe detail of algorithms. Finally, Chapter 6 is conclusion.

## 3. FRAMEWORK

From merits of Three Line Scanner Imagery for vehicle detection mentioned in chapter 1 and limitation of existing research, vehicle monitoring by using Three Line Scanner imagery has been developed under three objectives (See Figure 2 )

1. To detect stopped vehicle
2. To detect moving vehicle
3. To classify parked and signals waiting vehicles.

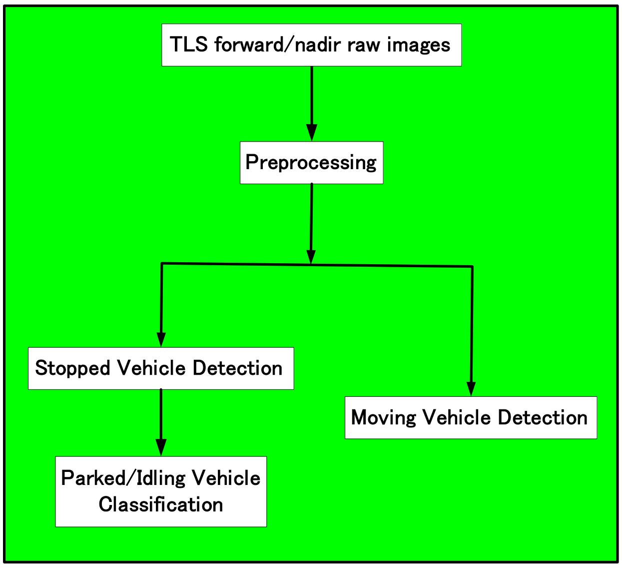


Figure 2 our framework of our vehicle detection algorithm

## 4. PREPARATION

**Pre-processing** is the preparation stage of fundamental information for further processing of vehicle detection.
At first, TLS raw images are geo-coded by Chen and Shibasaki algorithm in [2]. Secondly, road is located and non-road surface are masked in TLS image in [6]. By the parallel way, due to many building cast shadow areas in TLS image, building cast shadow on TLS raw image are delineated and corrected to obtain 'shadow-corrected image' in [7]. In our study, both 'raw image' and 'shadow-corrected image' are region-segmented to generate region-segmented image and shadow-corrected-region-segmented image. Regions are basic unit of further processing. However, under-segmented regions and noise still occur on both images. Therefore, under-segmented regions and noise are corrected by erosion of morphological operation and region-nearest interpolation to generate 'cleaned region -segmented image or cleaned image shortly' and 'cleaned shadow-corrected region- segmented image or cleaned shadow-corrected image shortly' respectively. At the latter step, regarding regions inside the road surface, all non-vehicles are rectangular polygon-fitted with rectangular properties such as width, length and length/width ratio etc. By these rectangular properties thresholding defined from vehicle dimension, non-vehicle regions are removed. Only on-street vehicle-likely regions exist finally. By using area-based stereo matching algorithm between TLS raw nadir and raw forward images, those rectangular-fitted polygon heights with matching correction are calculated in [5] Moreover, stopped and moving vehicle model hypotheses as explicit models are generated with generic character of stopped and moving vehicle in TLS single nadir images with vehicle dimensions under U.S. transportation law.

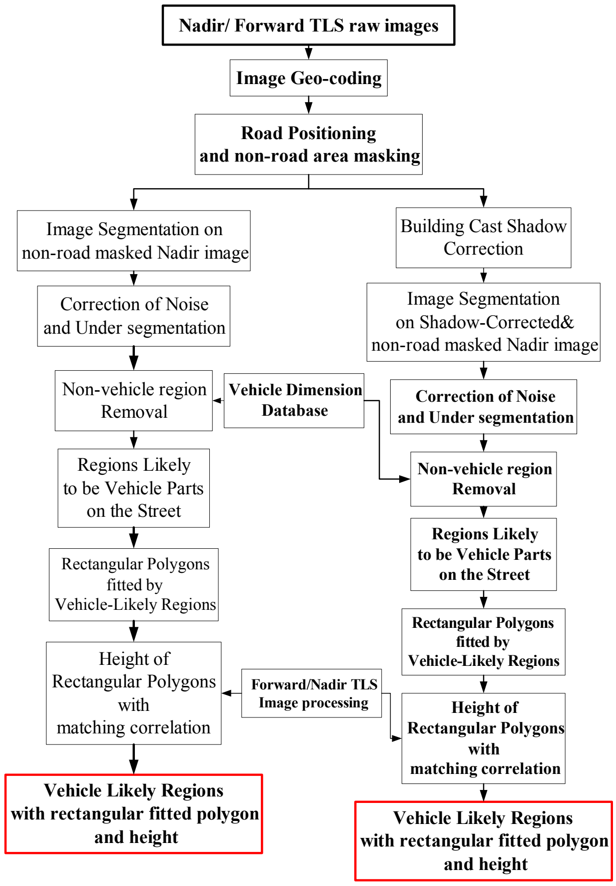


Figure 3 symmetric diagram of Preparation

## 5. STOPPED/MOVING DETECTION

**Vehicle detection stage** is the core of our study. Our algorithms consist of two approaches: Main approach and supplementary approach. Main approach is to detect moving /stopped vehicles automatically by using multi TLS images and to discriminate two classes: parked and idling vehicle class from stopped vehicles with on-street parking criteria. In case of omission from main approach, supplementary approach is to additionally detect vehicles from TLS single nadir image automatically and semi-automatically. Briefly, concepts of our vehicle detection approaches are mentioned as below;

**Stopped Vehicle Detection** is our proposed algorithm of stopped vehicle detection by using multi-TLS image processing. At first, from Pre-processing stage some on-street vehicle-likely regions are selected with thresholding of height-and-matching correlation. This kind of thresholding is defined by selecting regions which are higher than road surface obtained from pre-processing stage. However, those regions are independent. Therefore pair distances among Centre of Gravities of 'those selected regions' are calculated. Regarding pair distances, nearest regions are grouped roughly into a binary, hierarchical cluster tree by nearest-neighbour linkage algorithm.

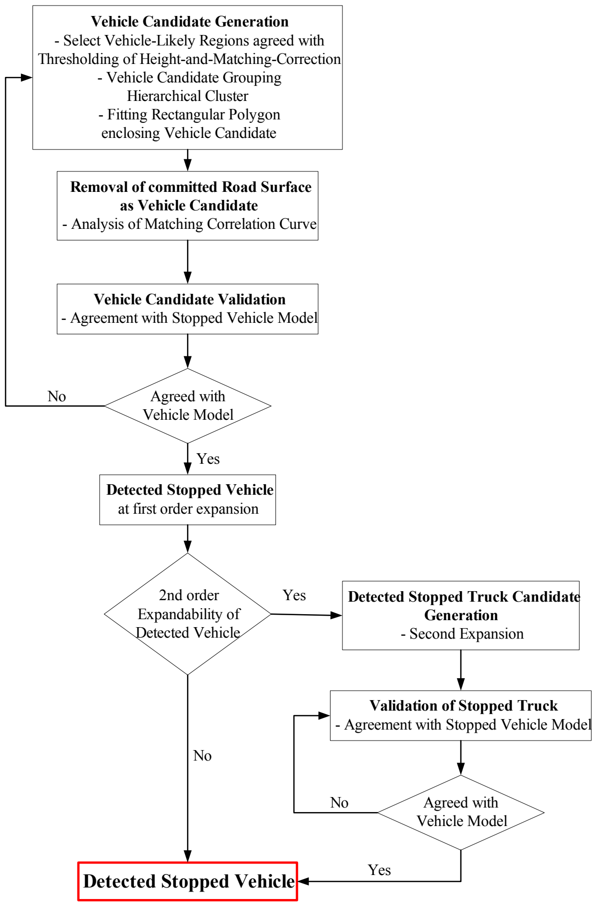


Figure 4 Systematic diagram of stopped vehicle detection

Figure 5 examples of Detected Stopped Vehicles

Vehicle candidate are generated by detecting natural nearest-region groupings in the hierarchical tree. Vehicle candidate regions are fitted with rectangular polygon by our rectangular polygon fitting algorithm and height of this rectangular polygon is calculated by area-based stereo matching algorithm. Vehicle candidates with their rectangular polygon and height, which are agreed with stopped vehicle model, are detected stopped vehicles.

**Moving Vehicle Detection** is our proposed algorithm of moving vehicle detection by using multi-TLS image processing. Firstly, vehicle likely regions of stopped vehicles and their neighbourhood regions along the road direction are removed by using neighbourhood relation network with road-direction constraint. Secondly, regarding non-vehicle likely region such as road surface regions at pre-processing stage, isolated vehicle-like regions surrounded by road surface regions without any neighbourhood vehicle-likely regions, which are not agree with vehicle width and orientation thresholding, are removed.

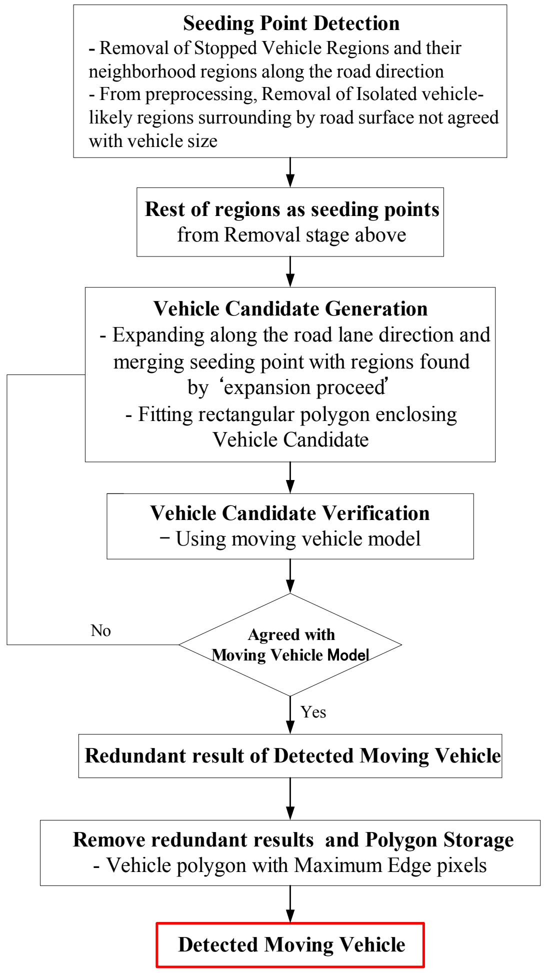


Figure 6 Algorithm of Moving Vehicle Detection

From two processing stages, the rest of vehicle-likely regions are the seeding points for the 'Expansion Proceed' algorithm of vehicle candidate generation at third stage. For the description of 'Expansion Proceed' algorithm, a selected vehicle-likely region as seeding point expands along road to detect neighbourhood vehicle likely regions between both sides of seeding point along road direction and then merge detected regions with seeding point to be generate one cluster or moving vehicle candidate. Also this vehicle candidate is fitted by rectangular polygon fitting algorithms.

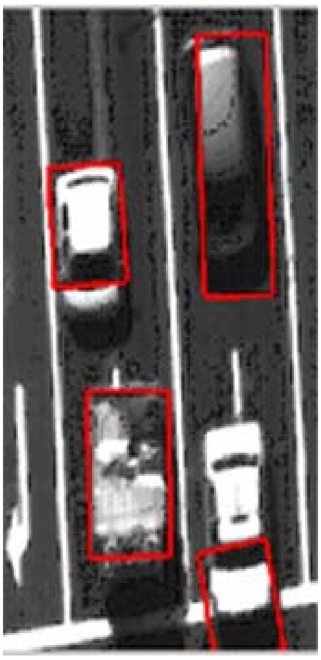

Figure 7 example of our algorithm of moving vehicle detection

By using this polygon, correlation of area-based stereo matching algorithm is calculated to measure degree of same vehicle matching on different directional TLS images because a moving vehicle is at different same position on Nadir, Forward or Backward TLS image. Finally, moving vehicle candidates with their rectangular polygon and correlation of matching, which are agreed with moving vehicle model, are detected moving vehicles.

## 6. PACKED VEHICLE DETECTION

**Parking/Idling Vehicle Detection** is our algorithm to discriminate parked and signals wait vehicle types. From all of four vertexes of each stopped vehicle polygon to both side of road edge known from pre-processing stage, on space domain, perpendicular distances are solved.

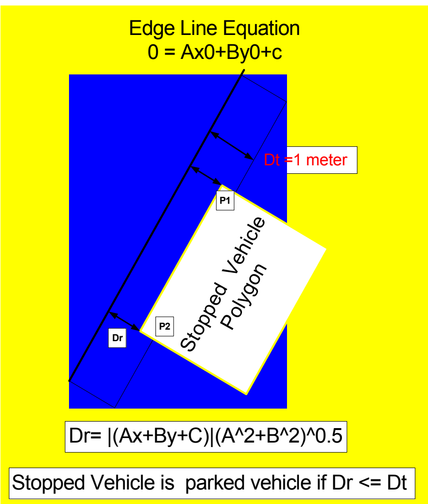


Figure 8 Concept of Parked Vehicle Detection

At least, one of all vertexes of each stopped vehicle polygon is agreed with Road Edge-to-Parked-Vehicle Distance Thresholding. Road Edge-to-Parked-Vehicle-Distance Thresholding is defined by the observation of on-street parking and signals waiting vehicles from the ground true survey.

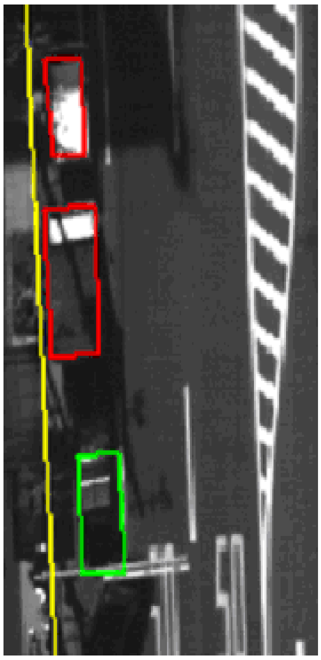

Figure 9 some result example of Parked/ Idling Vehicle Classification. Green polygon as Parked Vehicle and Red as Idling Vehicle

## 7. SURMERRY

Finally, our contribution presented new algorithms of vehicle detection by using new aerial image of Three Line Scanner. The algorithms perform the promising results. The improvement of algorithms is based on as below;

1. Stopped Vehicle Detection algorithm by using multi TLS image has been developed.
2. Moving Vehicle Detection algorithms by using multi TLS image has been created.
3. Parked/ Signals Waiting Vehicle Classification has been developed.

All of our new proposed vehicle detection algorithms perform robustness with promising results.

## ACKNOWLEGNE

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### References

1. Chellappa R., Zheng Q., Davis L., Lin C., Zhang X., and Rofield A., 1994, Site model based monitoring of aerial images , Image Understanding Workshop, pp.295-318

2. Chen T., Shibasaki R., 2001, Calibration and High Accuracy Georeferencing for Airborne Three-Line Scanner (TLS) Imaging System, 3rd International Image Sensing Seminar on New Development in Digital Photogrammetry, Gifu, Japan, Available: http://www.chikatsu-lab.g.dendai.ac.jp/wgv4/presentation/08_02Chen.PDF (accessed 22 Apr. 2004)
3. Hinz S., Baumgartner A., 2001, Vehicle Detection in Aerial Images Using Generic Features, Grouping, and Context, Chiar for Pkotogrammetry and Remote Sensing, Technische Unviseritat Munchen, Munchen, Germeny, http://www.photo.verm.tu-muenchen.de /site_lpf/site_new/download/pub/hinz_dagm01.ps.gz (accessed 22 Apr. 2004)
4. Hinz S., 2003, Combing Local and Global Features for Vehicle Detection in High Resolution Aerial Images , Technical Report PF-2003-02, Chiar for Pkotogrammetry and Remote Sensing, Technische Unviseritat Munchen, Munchen, Germeny, http://www.Fenerkundung-TUM.de (accessed 22 Apr. 2004)
5. Nakama K., Nakagawa M., Shibasaki R., 3 D Urban Mapping Based On The Image Segmentation Using TLS DAT, the 23rd Asian Conference on Remote Sensing, 25-29 November 2002, Available: http://www.gisdevelopment.net/aars/acrs/2002/urb/232.pdf(accessed 22 Apr. 2004)
6. Shi, Y., Shibasaki, R. 2003, a study on 3D road extraction from three linear scanner. The 24th Asian Conference on Remote Sensing Busan, Korea, CD-Rom
7. Sompoch P., Shibasiki R., 2002, A Study on Possibility of TLS image for Application to Road Monitoring on the street in the urban , Poster session No.1, Geoinformation Forum Japan 2002, Tokyo, Japan http://shiba.iis.u-tokyo.ac.jp/member/current/sompoch/Sompoch_papaper1.pdf(accessed 22 Apr. 2004)
8. Zhao T., Nevatia R., 2001, Car Detection in Low Resolution Aerial Image, ICCV 2001, http://iris.usc.edu/Outlines/papers/2001/tao_car_iccv-01.pdf (accessed 22 Apr. 2004)