

A Design Approach of Automatic Visitor Counting System Using Video Camera

Ali M. Ashkanani¹, Ali Sobhy M. Roza², Hadi Naghavipour³

^{1,2}(Electrical Engineering and Computer Science (EECS) Department, University of Toledo, 2801 West Bancroft Street, Toledo, OH 43606, United States)

³(Department of Computer System & Technology, Faculty of Computer Science & Information Technology, University of Malaya, 50603 Kuala Lumpur, Malaysia)

Abstract: Visitor counting system is counter based system that count the number of visitors comes to a specific area. This visitor counting system can be used at the entrance of the intended visitor counting area like market place, shopping mall, pedestrian traffic management etc. for counting total number of visitor. It is very important for getting information about how many visitors are present in a specific area at a given time. Visitors can be counted by using different types of sensors namely infra-red sensor, laser beam, video camera and thermal sensor. Literature shows that visitor can be counted accurate by using video camera with different video processing methods. This paper shows an approach of visitor counting system based on video camera. Images from video camera can be taken to computer via USB for different image processing and counting the visitors. This visitor counting system can be implemented in Matlab Simulink and with the help of image processing toolbox this system is able to count visitors efficiently.

Keywords: Visitor, Video Camera, Segmentation, Image processing

I. Introduction

Now-a-days, it is important to have the specific information about the visitors in a specific place like shopping mall, market place, departmental store, customer service center, and pedestrian traffic management etc. at any given time. This specific information can help to analyze visitors' traffic pattern and movements in a specific place. This specific information about the visitors can be collected by using visitor counting system. Visitor counting system can be defined as a process which is utilized for measuring the number of visitor passing by a specific area or specific passage of a specific location per unit of time. Visitor counting system has the ability to analyze the travel direction of the visitors. Large numbers of people are moving around in all direction in market place; railway platforms, customer service center, stations, shopping mall etc. and flow rate of this people within a specified region could indicate the amount of visitor crossing this region within a definite period of time. As mentioned earlier, visitor counting system has numbers of benefit. Visitor counting systems in the shopping mall is important to know about the number of visitor come in normal time as well as if there any promotions are given into that shopping mall, to analyze the success of the promotions and other merchandising activities visitor counting system is one of the important parameters. Also, in retail stores, counting is done as a form of intelligence-gathering. The use of visitor counting systems in the retail environment is necessary to calculate the conversion rate, i.e., it can help to collect the statistical information on the visitor flow at different periods of time over certain places. This is the key performance indicator of a store's performance and is superior to traditional methods, which only take into account sales data [1]. It is also important for customer service center because it can give the specific information about the customer satisfaction and success of the customer service center.

Optimization of staff shifts can be benefited by correct visitor counting system. Density of visitor traffic indicates the requirement of number of stuffs to serve them. Also, time selection of services like maintenance, cleaning and arrangement of goods are typically done when traffic of the visitors are lowest. More accurate visitor counting systems are also important for business research. It gives the market data about the visitors and by using this data investors can optimize their investment in specific market place for their business development. It always measure and analyze real time visitor traffic for business intelligence solutions. Precise data regarding visitor entry and exit activities can be found by the visitor counting system which allows users to make strategic decisions necessary for improving the performance of business. It benefits managers to realize issues affecting human traffic and thus plan and optimize resources effectively. These factors may include market research, special promotional activities, customer advertising campaign, new competition and renovation. Shopping mall marketing professionals rely on visitor statistics to measure their marketing. Often, shopping mall owners measure marketing usefulness with sales, and also use visitor statistics to technically measure marketing usefulness. In addition, visitor counting system can give the information about the number of visitor gather in railway platforms and stations at a specific timer or a certain period of time which reflects the

statistics of the effectiveness. Consequently, visitor counting system can give the information about the most visiting place of a country and from there tourist can get the information about the attractive visiting place of the country.

In recent times, real-time visitor counting system are showing very beneficial information for numbers of applications like people management or security service like pedestrian traffic management or tourists flow estimation. Visitor counting must be carried out correctly for analyzing store performance perfectly. It is a 'false economy' to select a people counting system on the basis of cost alone. As management consultant Peter

Drucker once argued that "If you can't measure it, you can't manage it." [2]. Moreover, many violent crimes have increased and become serious problems for many institutions and commercial areas all over the world [3]. Furthermore, visitors tracking and counting and analyzing their movements are important for the office security or the marketing research.

Aforementioned discussion shows that, visitor counting system is very important for so many reasons in recent era. So many research of visitor counting system is carried out recently [6-11]. Visitors are being counted manually [4]. This can be counted automatically in different ways by using different types of sensors namely infra-red sensor, laser beam, video camera and thermal sensor. Recently, video camera is being used for visitor tracking and counting because of the rapid development of the image processing algorithms and computer vision technology. Development of the real time interface devices in the simulation environment also another reason for this increasing uses of video camera for visitor counting system. This paper shows an automatic visitor counting approach using video camera. This is not a simple task, there are some situations difficult to solve even with today's computer speeds (the algorithm has to operate in real-time so it makes limits for the complexity of methods for detection and tracking). It is very hard to count the visitors when they enter or leave in a group at a certain place. This problem can be solved by the utilization of fast growing computer vision technology and high speed computer as a processor for counting. Visitors can be counted by taking continuous pictures by video camera and passing these real time pictures continuously to computer through USB connector for image processing. This image processing composes of segmentation, background elimination and blobs detection etc. and can be done in Matlab Simulink platform. Details of the process are presented in the paper and shows that, by this process visitor can be counted effectively.

Section II of this paper shows manual visitor counting system followed by automate visitor counting system in section III. Afterwards, brief overview of segmentation is shown in section IV. Block diagram of visitor counting system is shown in section V followed by detail description in section VI. Conclusions have been drawn in section VII.

II. Manual Visitor Counting System

Conventional method of visitor counting system is manual counting. Visitor can easily count the number of people passing a specified area by using counter. Even though visitor can be counted accurately within a short period of time, manual counting is labor intensive and highly costly [5]. Human labors have limited attention span and reliability when large amount of data has to be analyzed over a long period of time, especially in crowded conditions. It is also hard to deliver physical results in real-time for on-line surveillance. Consequently, it is necessary to develop the automatic visitor counting system and this is not a simple task, there are some situations difficult to solve even with today's technology.

III. Automated Visitor Counting System

Visitor counting is a challenging scientific problem and related to lots of practical applications like railway platform, monitoring the number of people sitting in front of a television set, counting people in the elevator, trains, counting the number of people passing through security doors in shopping malls, counting number of people presents in departmental store, counting number of visitor visit the recreation park and counting the number of people working in the laboratory. One of the automated methods of counting visitor is the microcontroller based counting system. Microcontroller based system normally used for counting for small scale, but for large scale and commercial use this system have some limitations like lack of accuracy. Also ultrasonic sensors can be used to count people, ultrasonic receivers can count the number of the people when it detects the echo bouncing off from the people within the detection zone. The accuracy of counting degraded when many objects walk across the detection region, especially person in front of the sensors blocked the detection of other people. Also microwave sensors and weight-sensitive sensors are one of the devices that can be used to count people. Due to rapid development of computer and computer vision system, it is possible to count people using computer-vision even if the process is extremely costly in terms of computing operations and resources. In general, counting people is important in surveillance based applications, market research and people management. People detection by means of artificial vision algorithms is an active research field. Three main research lines can be noted according to the distance of capturing people, thus limiting the number of people given in a captured image [6]. Today, a lot of researches have been published in order to resolve such

problem which is count people using video camera. This is not a simple task, there are some situations difficult to solve even with today's computer speeds (the algorithm has to operate in real-time so it makes limits for the complexity of methods for detection and tracking). But, high speed computer as a processor and rapid development of computer vision and image processing algorithm make it comparatively easier to solve this problem.

IV. Segmentation

One of the most crucial steps in many engineering applications of computer vision is that of segmentation. Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images. Processes of image segmentation from Matlab Image processing Toolbox are shown in the following flowchart:

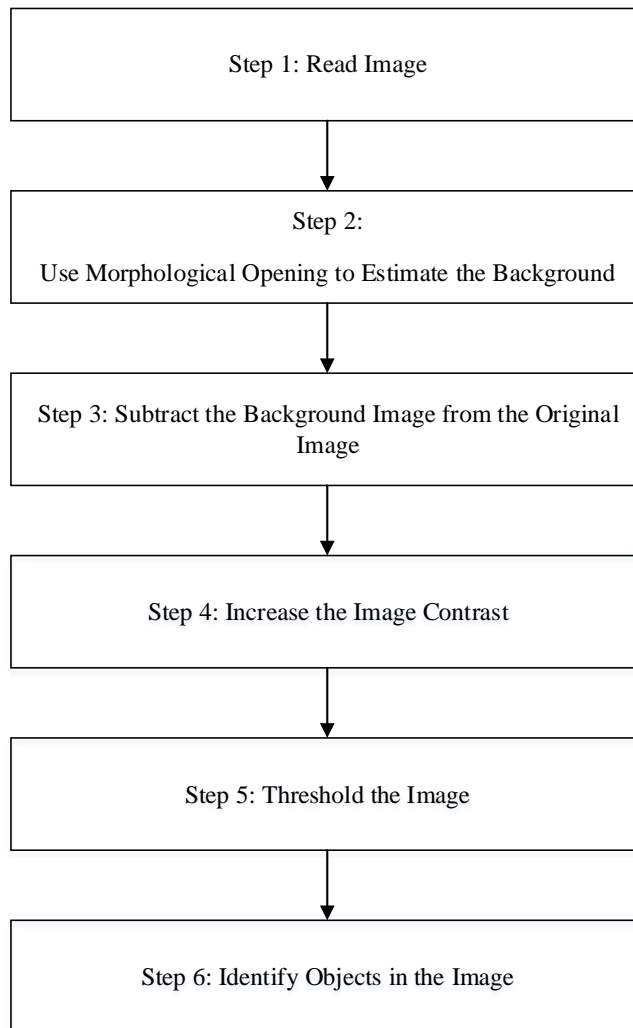


Figure 1: Flow chart of segmentation to detect the object

Fig 1 shows the flow chart of example of the segmentation process for identifying the object of the image in Matlab Image processing Toolbox. At the beginning of the process image is being read from the video camera. Fig 2(a) shows the original image from video camera. After reading the image from camera, background of the image is estimated which is shown in Fig 2(b) After the estimation of the background, background is subtracted from the original image which is shown in Fig 2(c) After this, contrast of the image of Fig (c) is increased which is shown in Fig 2(d). After this, a new binary image is created by thresholding the adjusted image and noise removing of background is take place which is shown in Fig 2(e). From this binary image, objects of the image are counted.

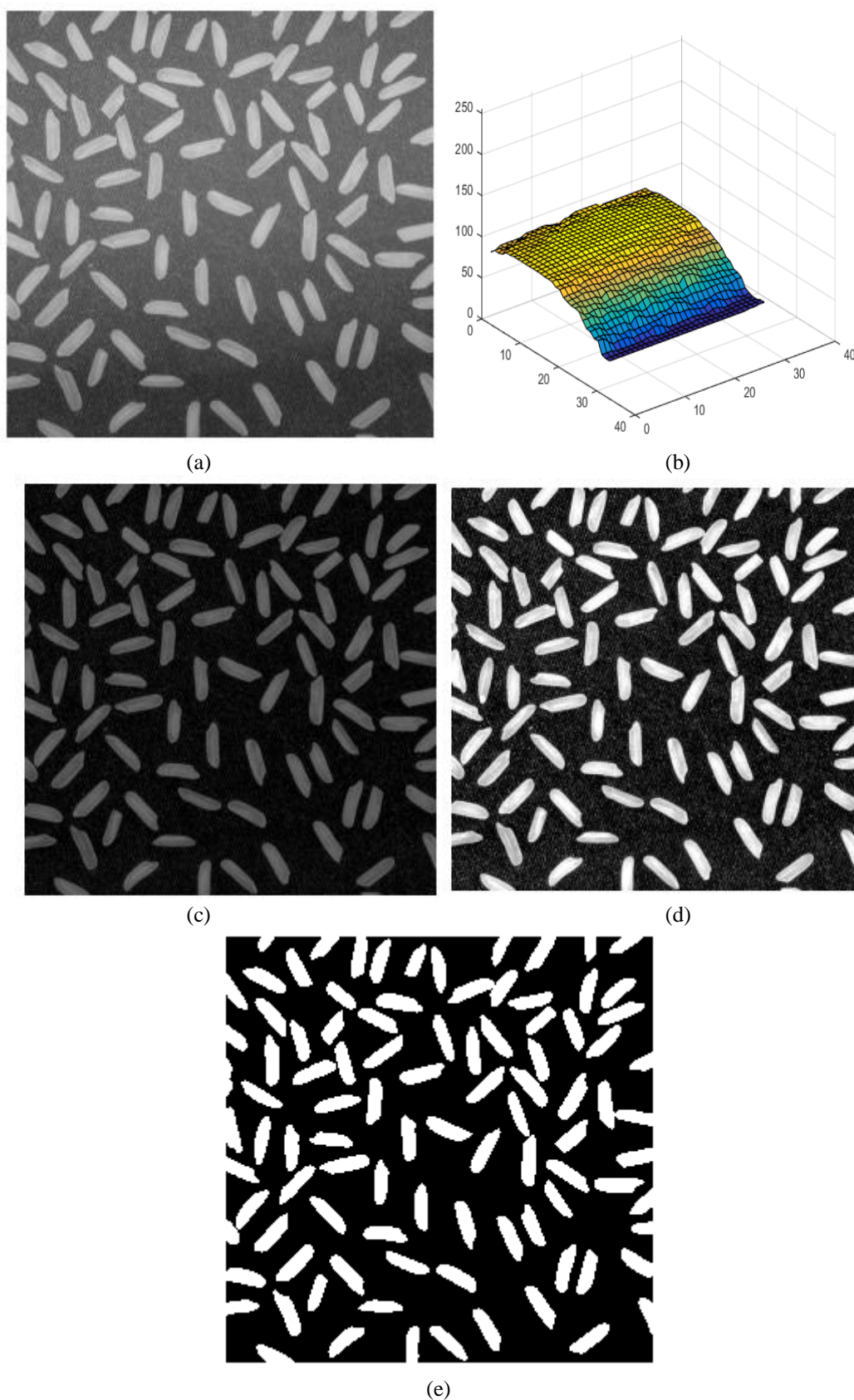


Figure 2: Example of segmentation process to identify object (a) Original Image, (b) Estimated background of the image, (c) Image after subtracting background from the original image, (d) Image after increasing contrast, (e) Image after removing background noise.

V. Visitor counting system

Fig. 3 shows the flow chart of automatic visitor counting system algorithm. Video camera has been introduced here for automatic visitor counting. The images from video camera are taken to computer via USB connection for analysis. After getting the image from camera, background of the image is estimated for segmentation. After performing segmentation of the images, the information are passed through a decision making algorithm for tracking and counting the visitor to stop the counting process. Details of the process have been discussed in the following sections.

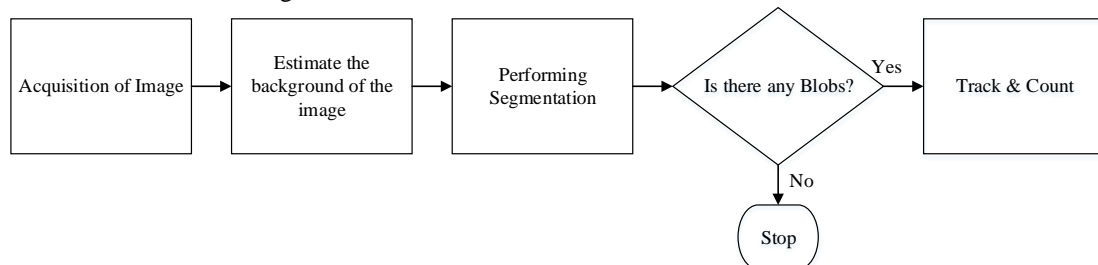


Figure 3: Flow chart of automatic visitor counting system

VI. Description of the Visitor Counting System

Details process of the Visitor counting system is shown in Fig. 4 Image is the first requirement at the starting of this visitor counting system and for this reason image has been taken from video camera and transformed into gray-scale image for analyzing. Differencing frame of the images is the first steps of this visitor counting algorithm. Frame differencing is the process of making pixel by pixel absolute differencing between two consecutive frames which in turns results in a new image which depicts all the differences between this two consecutive frames. Motion can be detected by this image difference. There must be modifications between the consecutive frames if it's not an empty image (a full black image) so there is motion in the field of the video camera. Background estimation is another important process of visitor counting system. A reference image for estimating background part of the scene is created by background estimation algorithm. For detecting and tracking moving objects the background image is necessary and this will be used to separate the background and the foreground. Estimation of this background should be dynamic meaning background must be updated regularly which is very important consideration for good real time visitor counting system algorithm. For instance, if the visitor counting system is carried out in the entrance of shopping mall, some little and gradually modifications happen throughout the day and cans parasite the visitor counting algorithm (more particularly the background difference algorithm).

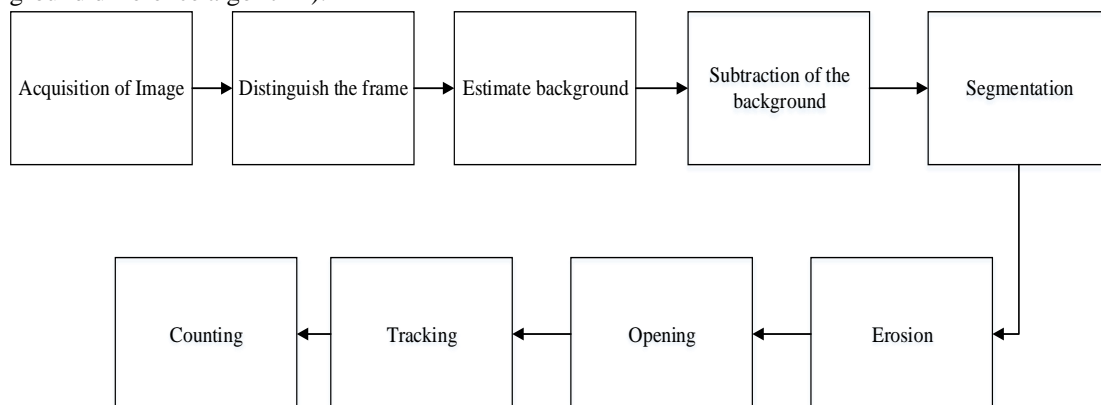


Figure 4. Block diagrams of the detail processes of the visitor counting system

During the days light intensity of the sun changes and for this reason some objects can be added or removed in the scene. For this reason background estimation should be updated time to time otherwise visitor counting algorithm will fail to detect the variations. At the very beginning of the background estimation, the visitor counting algorithm must be certain that there is no motion in the video camera field during this time. The reference image must be updated when there is no motion. On the other hand, if there is existence of motion in the video camera frame, the background image must not update and should try in the next time of estimation of the background.

After finishing the estimation of the background, the algorithm then look forward for separating the foreground and the background. Here, at this stage of the algorithm, large variation between the present background and the image of the video camera is represented by the foreground. Algorithm for frame

differencing is quite similar with this process but have some differences. Frame differencing algorithm faces some difficulties to separate the foreground and the background of the image (difference between two consecutive frames) due to the tendency to just highlight the edges of objects in the foreground which makes the image analysis more difficult afterwards. Standing objects can be detected by differencing algorithm which is another limitation of this algorithm. Therefore, objects are detected by background subtraction process and motion is detected by differencing frame in visitor counting system.

Erosion is the next morphological operation which is used for eroding away the boundaries of the several regions of the foreground. As a result, objects of the foreground region will become smaller (some of them will entirely be disappeared) and holes in objects will be bigger.

Combination of two basic operations Erosion and Dilatation are called opening operation and the primary objective of this operation is to remove noise as well as separation of blobs that are linked with small layer.

As mentioned earlier, the important steps of the image processing algorithm is the Blobs detection for efficient tracking of the objects in scene. After analyzing binary image all the blobs can be detected. Typically, the blobs features usually calculated are area (number of pixels which compose the blob), perimeter, location and blob shape.

Segmentation quality maintains the performance of the blob analysis algorithm. The better the segmentation the better blobs detection and vice versa. Due to bad segmentation, some blobs can be merged or some extra blobs can be detected because of the different lighting condition.

Counting is another important process of visitor counting system. The counting process involves for deciding blobs direction. This process have two different direction in case of video camera namely visitor IN and visitor OUT. These two directions can be represented by two virtual lines. If the blobs cross the specific virtual line the counter increase the corresponding counter value. Oppositely, if the blobs cross the other virtual line, the counter decrease the value as it can memorize the value. In this way, visitor can be counted in specific places.

VII. Conclusion

The visitor counting system is combination of four subsystem of background process, segmentation, tracking and counting. This paper shows an approach to count visitor passing through a specific place by using video camera. This visitor counting system can be easily implemented in Matlab-Simulink programming tool with a high configuration computer and can able to count the visitor in real time. This process can be good alternative of the traditional sensor based visitor counting system. This system consists of several good applications of image and video processing which are the important tolls of computer vision systems. This visitor counting system can be utilized in several places like shopping mall, departmental store, recreational park, railway platforms, stations and so many places for counting visitor and gather idea about the present people in a specific place. This approach is very import for market research to analyze the effectiveness of business policy.

References

- [1]. K. Terada, D. Yoshida, S. Oe, and J. Yamaguchi, "A method of counting the passing people by using the stereo images", International conference on image processing, pp. 338-342,1999.
- [2]. Byrne, John A.; Gerdes, Lindsey (November 28, 2005). "The Man Who Invented Management". BusinessWeek. Retrieved November 2, 2009.
- [3]. NPA White Paper: <http://www.npa.gov.jp/hakusho>.
- [4]. K. Terada, D. Yoshida, S. Oe and J. Yamaguchi." A counting method of the number of passing people using a stereo camera", IEEE Proc. of Industrial Electronics Conf., Vol. 3, pp.1318-1323, 1999.
- [5]. B. Son, S. Shin, J. Kim, and Y. Her "Implementation of the RealTime People Counting system using Wireless Sensor Networks", International Journal of Multimedia and Ubiquitous Engineering, Vol. 2, No. 3, pp. 63-79 July, 2007.
- [6]. A. Vicente, I. Muñoz, P. Molina, and J. Galilea "embedded vision modules for tracking and counting people", IEEE transactions on instrumentation and measurement, vol. 58, no. 9, pp. 3004-3011, September 2009.
- [7]. L., Damien, "Real-Time People Counting system using Video Camera", Master of Computer Engineering Thesis, Image and Artificial Intelligence, Department of Computer Science and Media Technology Gjøvik University College, Norway, 2007.
- [8]. X. Liu, P.H. Tu, J. Rittscher, A. Perera, and N. Krahnstoever, "Detecting and counting people in surveillance applications," IEEE Conference Advanced Video and Signal Based Surveillance, pp. 306-311, 2005.
- [9]. D. Geronimo, A. M. Lopez, A. D. Sappa, and T. Graf, "Survey of pedestrian detection for advanced driver assistance systems," IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI), vol. 32, pp. 1239-1258, July 2010
- [10]. A. Geiger, M. Roser, and R. Urtasun, "E_icient large-scale stereo matching," in Asian Conference on Computer Vision (ACCV), (Queenstown, New Zealand), November 2012.
- [11]. L. Ladick_y, P. Sturgess, C. Russell, S. Sengupta, Y. Bastanlar, W. Clocksin, and P. H. S. Torr, "Joint optimization for object class segmentation and dense stereo reconstruction," International Journal of Computer Vision (IJCV), 2011.