International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 20 (2017) pp. 9723-9727
© Research India Publications. http://www.ripublication.com

Study on Vehicle Accident Avoidance System Using Kinect Depth Sensor Along with Notifications on Mobile Devices

Niyonsaba Eric* and Jong-Wook Jang**

, Department of Computer Engineering, Dong-Eui University, Busanjin-Gu 614-714, Busan, Korea.*

Abstract

In this paper, Kinect depth sensor, a low-cost range sensor released by Microsoft is used as vision sensor to monitor vehicle's surroundings by detecting objects in front of it and measuring how far they are from the sensor. Therefore, our monitoring system comes with computer vision techniques which imitate natural human vision system letting unmanned (robots) or manned vehicles to understand the environment around them by extracting and analyzing useful information from a single or a sequence of images taken by cameras, here Kinect camera. Several technologies have been used to deal with computer vision applications such stereovision, LIDAR and RADAR but each of them still has advantages and disadvantages in term of limitations and price. Firstly, experiments have been conducted with Kinect depth sensor by detecting the obstacles in front of the sensor and measuring the distance from them to depth sensor in accuracy way by checking if the detected object is real or not to reduce processing time ignoring pixels which are not a part of real object in such real-time applications. Results are promising and also Kinect accuracy have been tested on distance measurement function based on the location of detected object, different environments (brightness and darkness), physical measurements and system outputs. In our case, we suppose a vehicle equipped with Kinect camera as imaging sensor in order to take more precautions to avoid accident by helping the driver to be warned with simple message or an audio about some objects in front of the vehicle or get proof in case of accident that the driver didn't take care or not by saving color images and distances in web server whenever there is a warning. Also, a mobile application on android platform is developed to get notification whenever there is a warning about the presence of objects and at the same time distances and color images are recorded in web server for further analysis. Notification system can be used in many scenarios in case the driver is not the vehicle owner and also in parking area when the owner is notified in real time when other vehicle comes closer at a certain distance and can view the color image of the scene simultaneously when there is a warning.

Keywords: Kinect depth sensor, Depth segmentation techniques, Object detection with Kinect v2, Distance measurement with Kinect v2, Monitoring system, computer vision.

INTRODUCTION

Normally, natural vision comes with living beings like humans who use their eyes and their brains to control the word around them and computer vision [1], artificial vision comes in the similar way by imitating human vision with artificial intelligence techniques which involve the development of a theoretical and algorithmic basis to achieve automatic visual understanding. Computer vision has been an interesting field and is undergoing research so far and its applications are numerous including collision avoidance [2], autonomous vehicles, industry quality inspection, face recognition, medical image analysis, surveillance systems etc. One of the integral tasks in computer vision is to perceive the word as human do, detect objects in vision sensor's field of view and estimate the distance from where those objects are located. Many techniques along with different vision sensors have been used for computer vision applications including Stereovision, LIDAR (Light Detection and Ranging) and RADAR (Radio Detection Ranging) [3] but still each of them has its own advantages and disadvantages. Finding the distance between the camera and detected objects within camera's field of view, which is the main purpose of the present research, is an ongoing field of research given the fact that there isn't a perfect solution yet and computer vision prefers to use depth cameras rather image intensity cameras since depth information makes the variety of applications more feasible and robust. In this paper, we chose to make experiences with Kinect sensor, a low-cost depth sensor for detecting objects in its field of view and measuring how far away they are from the sensor.

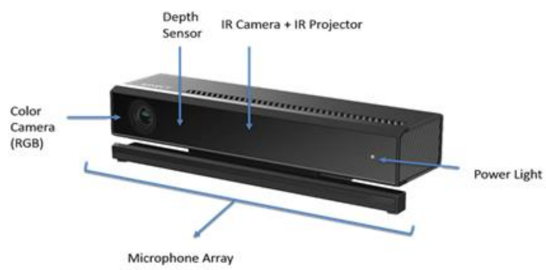

Figure 1. Kinect version 2 architecture

Kinect camera (as shows Figure1) consists of different parts w ith specific tasks. The color camera is responsible for capturing a nd streaming the color video in order to detect the red, blue and g reen colors from Kinect with a resolution of 1920x1080 pixels whereas the depth sensor generates the depth information of the object in front of the Kinect with a resolution of 512x424 pixels [4]. Meanwhile the infrared emitter (IR camera and IR projector) allows the sensor to view light-independently. It has a higher depth in comparison with the first version, fidelity and a significantly improved noise floor, and by providing 3D visualization, we are able to see smaller objects and all objects more clearly [5]. As Kinect v2 uses Time-of-Flight system, it modulates the camera light source with a square wave by using phase detection to measure the time the light takes to travel from the light source to the object and back to the sensor [6] and the depth is then calculated based on the speed of light in air.

Firstly, Kinect camera was released as an interface device to interact with consoles in order to avoid hand-controller devices during games to transform player’s movements and voices into controls with its capabilities to stream depth image, color image, emit infrared and input audio. It was basically used for tracking human body’s movements, gestures and spoken commands during game but now due its depth sensor, it comes as essential tool in computer vision field. Computer vision has been used in many specific applications such as multimedia database search engines [7] using attributes such as colors and shapes instead of text-based retrieval queries for images. In medicine, computer vision can alert clinicians and assist doctors during results interpretation to reveal some abnormalities on medical images [8]. Surveillance systems are also based on computer vision techniques in public places like airports and transport stations. In factories, computer vision can even monitor workers and track anyone who is not paying attention to a potentially dangerous part of a task [9].

Depending on these applications mentioned above, computer vision relies on different vision devices and techniques. In the literature review, we can so far identify many applications related to computer vision with different vision devices. Computer vision is improving in the technology with range cameras in human-computer interaction, robotic and machine vision, autonomous vehicles as well as in augmented reality. According to Jernej Mrovlje and Damir Vrancic [10], distance measuring sensors are divided into active and passive categories. Active methods (laser beam, radio signals, etc.) used as geometric sensing, measure the distance by sending some signals to the surface of the object whereas passive ones receive information from detected object using light. In their experiments, they used a passive technique, stereoscopic measurement method to find distance to object but this method requires two cameras and has more restrictions. Giulio Reina and Annalisa Milella [11] have experienced making agriculture robots based on multi-baseline stereovision. They found out that even the system has advantages, there was a need of good light to make clear the field of view and also its algorithms are very complicated with a high computation cost which makes slow systems in real time. The background and the obstacle are very hard to separate. LIDAR and RADAR sensors have been used as obstacle detection for autonomous vehicles but they are very expensive and this prevents researchers to use such sensors. Lots of applications seem to deal with object tracking but in this paper another parameter is added, distance value in accuracy way by minimizing processing time and ignoring noise pixels from detected objects which can be helpful for vehicles with a low cost depth sensor when they reach a certain distance from detected objects and in this case, a monitoring application is carried out using it and mobile devices based on notification system.

RELATED WORK WITH KINECT VERSION 2

Even though Kinect v2 was mainly developed by Microsoft as interface for gaming with Xbox One console, its depth sensor based on Time-of-Flight principle has made it popular in the scientific community and researchers have tested and used it in many fields. In [12], authors have tested the capacity of Kinect v2 in order to find out if it could be an alternative to laser scanners for 3D measurements. They concluded that achieved results based on measurement precision and outdoor efficiency and that Kinect can be seen as a real progress for computer vision applications. Another test in [4] have been made for investigating Kinect’s properties including depth accuracy and authors obtained that Kinect has a good accuracy for objects which are placed near the sensor. Also, authors found that there are some parameters which limit Kinect’s performance such as object with reflective material like mirror and light-absorbing materials. Those kind of objects make the IR (Infrared) light emitted by Kinect sensor difficult to be reflected back to the camera for depth measurement.

To sum up, Kinect for windows sensor v2 shows with its low price a great potential to be applied in computer vision applications. Therefore, we can find in the literature review some of researchers using Kinect v2 in different applications. Tracking an object’s 3D location has been possible at low-cost by using Kinect sensor[13] whereas 3D object tracking was reserved before for users who can afford high-cost motion tracking systems such as Vicon system which is priced upwards of $10.000. Authors showed that object tracking can be performed in real time by using depth and color data from Kinect sensor priced cheaply at around $129. Tracking object has many applications in computer vision such as surveillance [14], pose and facial recognition [15] etc. and this makes Kinect a useful tool in many fields.

Kinect for windows sensor v2 has been also used for autonomous vehicles such as in SLAM (Simultaneous Localization and Mapping) systems [16] which is a major function in computer vision and robotics by using both depth and color images from a low cost sensor. Also in [9], Kinect has been mounted on a mobile robot for navigation and authors appreciated such system which allows mapping algorithms to model the environment and detect obstacles. In [17], Kinect has been used in healthcare systems for blind navigation support system and real-time monitoring of activities for people with mental illnesses which is a difficult task when it comes to be operated by a clin ician. Kinect was used also in agriculture activities [3] to reduce human involvement for harmful activities in a greenhouse environment such as using some products for spraying or fruit collection which requires a high degree of autonomous system. It is obvious that Kinect v2 has attracted many researchers in different domains and seems producing promising results.

SYSTEM DESIGN AND EXPERIMENT RESULTS

The main purpose is to detect objects within Kinect sensor's field of view and take their depths from where they are located. Here, Kinect depth sensor as shows Figure.2 is considered as a vision sensor connected to a computer system for distance measurement function of an entire autonomous system. Design system shows whole field of view of Kinect camera and also target area delimited by depth range to test the consistency of Kinect depth sensor in different intervals.

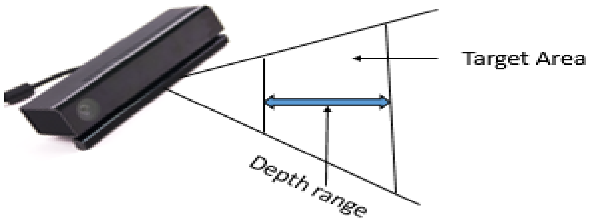

Figure 2. System Design of object detection and distance measurement functions

As long as frames are streaming from Kinect camera, present objects in its field of view are identified with a red rectangle using image processing functions and the depth sensor processes the distance measurement system from a nearest pixel of each object. In this section, results from our system using Kinect sensor in front of some objects are shown along with some settings indicating in which range user wants to detect objects and how should be the minimum size of tracked object because size have important effects in terms of processing time specially for real-time applications.

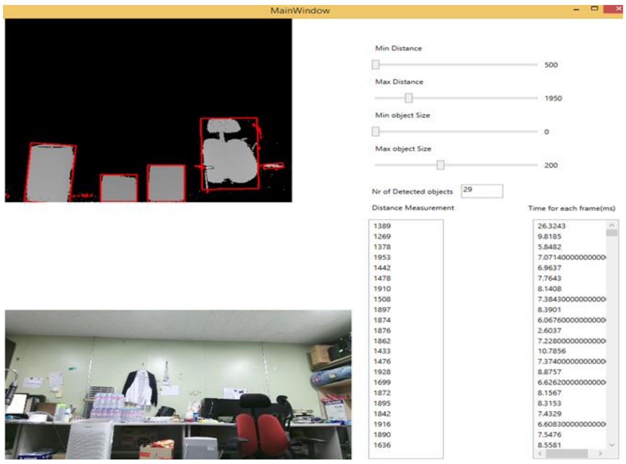

Figure 3. Tracked objects in Kinect's field of view

The first impression here on Figure 3 is the number of 29 tracked objects within 500mm to 1950mm range. This is because the minimum size of objects is set to zero and Kinect tends to identify some simple pixels which are not really objects but simply can be considered as noise as we can note on the corresponding color image. The drawback of this is that Kinect takes much time to process all detected objects but here we need real time system. To overcome this kind of drawback is to set a reasonable minimum size of detected object which can be real object in order to minimize the processing time. The processing time of each depth frame is shown. The first frame takes much time (26 ms) because of "background noise" activity in .NET framework. Therefore, the first time a method is launched in .NET, the time taken by that activity is added to the time of execution.

The minimum size of detected object is increased to 13 and the result can be seen on Figure 4.

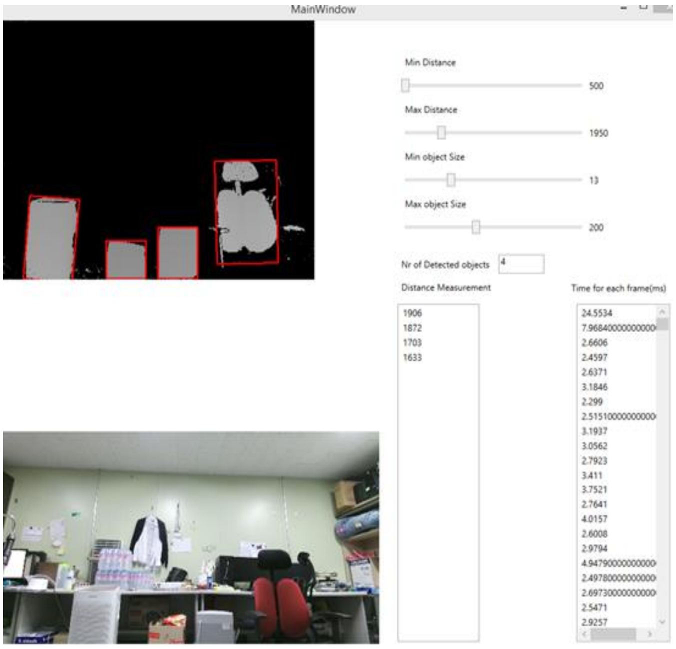

Figure 4. Tracked objects with minimum size of 13

On Figure 4, we can identify 4 real objects within a zone delimited from 500 mm to 1950 mm instead of all Kinect's field of view as we will discuss later the importance of detecting objects in a specific area based on the distance one wants to avoid between the sensor and the detected objects. Another parameter here is the processing time which has been minimized from an average of 7 ms on Fig .3 to an average of 2 ms on Figure 4. During our experiments, a distance variation between 8mm and 25mm for one detected object in same scenarios has been observed and this was the subject to assess Kinect accuracy for distance measurement function. Based on our results, applications which are very sensitive on distance measurement or even tolerate at least 8 mm, Kinect sensor seems not useful otherwise outputs are promising even in comparison with physical measurements.

NOTIFICATION SYSTEM ON MOBILE DEVICES

On Figure 5, we can realize that whenever there is a detected object in Kinect camera's field of view according to the settings, the user can get a notification on his mobile device wherever it is connected to internet.

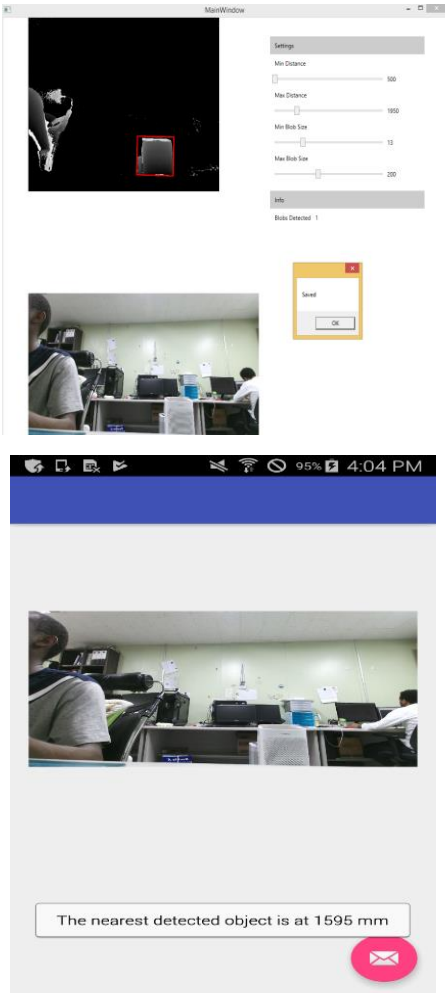

Figure 5: Detected object along with a notification on mobile device

Based on its capabilities, Kinect depth sensor may have many applications based on object detection and distance measurem ents functions and here it is used for monitoring system. In this case, we suppose a vehicle equipped with Kinect depth sensor in order to take more precautions to avoid accident by helping the driver to be warned about some objects in front of the vehicle or get proof in case of accident that the driver didn't take care or not by saving color images and distances in web server whenever there is a warning.

CONCLUSION

The purpose of this work was to develop object detection and dist ance measurement, two main functions using Kinect sensor, a lo w cost depth sensor and apply to some applications here for a mo nitoring system on vehicles. Results from Kinect accuracy evalua tion are promising even though there is a variation in distance fro m the same detected object and so many systems may use this de pth sensor such as vehicles to understand their surroundings by d etecting present objects and measuring how far they are for furthe r processing. In general, based on two main functions (object dete ction and distance measurement), Kinect may have many applicat ions in computer vision field.

ACKNOWLEDGMENTS

This research was supported by the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the Grand Information Technology Research Center support program (IITP-2017-2016-0-00318) supervised by the IITP(Institute for Information & communications Technology Promotion) and Human Resource Training Program for Regional Innovation and Creativity through the Ministry of Education and National Research Foundation of Korea(NRF-2015H1C1A1035898).

REFERENCES

[1] The British Machine Vision Association and Society for Pattern Recognition (BMVA), what is computer vision? http://www.bmva.org/visionoverview.

[2] Stefania, M. and Gianluigi, F., Low-complexity UWB-based collision avoidance system for automated guided vehicles. *ICT Express*, 2 (2016), 53-56

[3] Sharon, N., Jacob, G. and Victor, A., Obstacle detection in a greenhouse environment using the Kinect Sensor. *Journal of Computers and Electronics in Agriculture*, 113(2015), 104-115.

[4] Li, Y., Longyu, Z., Abdulhameed, A. and Abdulmotaleb E. S., Evaluating and Improving the Depth Accuracy of Kinect for Windows v2. *IEEE Sensor Journal*, 15(2015), 4275-4285.

[5] ALABBASI, H. A., Moldovenau, F., Moldovenau, A. and Shhedi, Z., Facial Emotion Expressions Recognition with Brain Activities using Kinect sensor v2. *International Research Journal of Engineering and Technology (IRJET)*, 2(2015), 421-428.

[6] John, S. and Patick, O., The Xbox One system on a chip and Kinect sensor. IEEE Micro, 2(2014), 44-53.

[7] Thomas, F., Patrick, M., Michael, K., Joyce, C., Alex, H., David, D. and David, J., A Search Engine for 3D M odels. *Journal of ACM Transactions on Graphics (TOG)*, 23 (2003), 83-105.

[8] Petrick,N., Berkman,S., Samuel G. A., Alberto, B., Loredana, C., Silvia, D. and Matthew T. F., Evaluation

of computer-aided detection and diagnosis systems. *Medical physics Journal*, 40(2013)..

[9] Research at the University of Maryland, "Computer Vision: Visual-Event Recognition for security and science". Available online: http://www.research.umd.edu/sites/default/files/documents/brochures/computer-vision.pdf.

[10] Manaf, A. M., Amera I. M. and Faris A.K., Object Distance Measurement by Stereo Vision. *International Journal of Science and applied Information Technology*, 2(2013), 5-8.

[11] Giulio, R., and Annalisa M., Towards Autonomous Agriculture: Automatic Ground Detection Using Trinocular Stereovision. *Sensors (Basel) journal*, 12(2012), 12405-12423.

[12] Elise, L., Hélène, M., Tania,L., and Pierre, G., Assessment and Calibration of a RGB-D Camera (Kinect v2 Sensor) Towards a Potential Use for Close-Range 3D Modeling. *Remote Sensing*, 7(2015),13070-13097.

[13] Michael Fleder, Sudeep Pillai and Jeremy Scott, "3D Object Tracking using the kinect", MIT Computer Science and Artificial Intelligence Laboratory. Available Online : https://people.csail.mit.edu/spillai/data/papers/cvclass-project-paper.pdf

[14] Ravishankar, S., Anoop, C., Joshua, F., Nicholas, W., and Nathaniel, B. A Multi-sensor visual tracking system for behavior monitoring of At-Risk children". *IEEE International Conference on Robotics and Automation*, 2012, pp.1345-1350.

[15] Karl, P., Vladimir, I., and Eduardo, R. Real-time object pose recognition and tracking with an imprecisely calibrated Moving RGB-D camera. *IEEE/RSJ International conference on intelligent Robots and systems,* 2014, pp.2733-2740.

[16] Olivier, W., Maecel, M., and Didier S. CoRBS:Comprehensive RGB-D Benchmark for SLAM using Kinect v2. *IEEE Winter Conference on Applications of Computer Vision* (WACV), 2016, pp.1-7.

[17] Victor, F., Hugo, F., Filipe, F. and Joao, B. Blind navigation support system based on Microsoft Kinect. *Procedia Computer Science* , 14(2012) 94-101.*

* *Corresponding author: Jang Jong-Wook, Ph.D.*
Department of Computer Engineering, Dong-Eui University,
Busanjin-Gu 614-714, Busan, Korea
E-mail: jwjang@deu.ac.kr