Wireless Transmission of Stereo Images and its Disparity Levels

Apurva Naik, Keshav Velhal, Kunal Shah, Pratik Raut, Arti Khaparde
Department of Electronics and Telecommunication
Maharashtra Institute of Technology
Pune, Maharashtra, India
Emails :{apurva.naik, arti.khaparde} @mitpune.edu.in; {keshav.velhal, pratikraut15.11}@gmail.com; {kunds18}@yahoo.com

***Abstract*— One of the promising application of wireless transmission is in Computer Vision. Real-time stereo images are captured using camera and transmitted to another system by using ZIGBEE wireless module. Before transmission, image pixels are grouped to form packets. These packets when received at the receiver end are recovered, and a 3-D image is generated. Also at the transmitter, images are segmented by using DPSO (Darwinian Particle Swarm Optimization). Segmented images are given to the line growing algorithm. Depth levels are estimated with the help of disparity values obtained from the disparity algorithm. These depth levels are transmitted through ZIGBEE module to another system. Depth levels received are used to control a ROBOT. This proposal is a prototype which can be implemented for industrial applications. The present paper deals with the Transmitter-Receiver link for stereo images and movement of ROBOT proportional to estimated depth levels.**

Keywords-ZIGBEE; Darwinian Particle Swarm Optimization; ROBOT.

I. INTRODUCTION

A two-dimensional camera image does not give information about depth levels. However, information about depth is required in several applications such as, satellite imaging, robotic vision, target tracking and automatic map making. Stereo matching is used to extract depth information from images [1]. These estimated depth levels can be used to control the movement of a ROBOT that can be used in robotic vision applications. Until recently, stereography was used either for entertainment purpose or DEM (Digital Elevation Model) for depth analysis of sea bed as, no evidence was found in literature on wireless transmission link for transmission of disparity levels. But this novel approach will help us to control the unmanned vehicle to perform the numerous tasks in medical, mining applications and in volumetric analysis of water reservoirs, etc., which requires the knowledge of depth. For example, one of the applications that can be developed is for computer-aided surgery. Images can be captured with help of stereoscopic endoscope. These images can be transferred to the control room. By doing an analysis and using depth information, the surgeon can instruct a ROBOT to perform certain tasks.

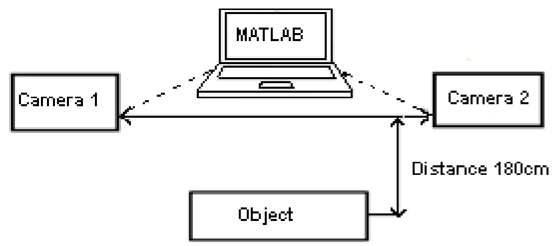

Figure 1. Block diagram of camera setup.

For capture of real-time stereo images, the distance between two webcams should be at least 6cm [7], which is approximately equal to the distance between centers of human eyes, i.e., 2.5inches, as shown in Fig. 1. The camera should be placed at a distance of 1.8m from the object to be captured.

For estimation of the focal length camera calibration, the toolbox of MATLAB [3] has been used. For estimating the focal length of the camera, four images of a chess board, each image having different orientation from the other were taken. A procedure [3] was followed and the focal length obtained was approximately 1300 pixels. Real-time images were captured through camera and processed using image acquisition toolbox of MATLAB. Pixel values of the images were grouped into packets of 2000 pixels and transmitted using AT transmission mode of ZIGBEE. Also, disparity estimation was carried out and depth levels were calculated. These depth levels were also transmitted using ZIGBEE. The maximum value of each depth level received was used to control the ROBOT movement. At the receiver end, a good quality 3-D image was reconstructed.

The rest of this paper is organized as follows. Section II describes the experimental setup. Section III describes the ZIGBEE module and its protocol, and ROBOT control. Section IV gives details of results. Section V concludes the paper.

II. EXPERIMENTAL SETUP

Experimental setup consists of 2 webcams, 2 general purpose PCs, 1 PC controlled wired ROBOT, 2 ZIGBEE modules (one coordinator node and one router node). ZIGBEE modules have been used for transmission of real-time images and depth values. In the present setup, ZIGBEE module of DIGI Company (XBee RF Modules) is used. ZIGBEE standard operates on the IEEE 802.15.4 physical

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radio specification and operates in unlicensed bands including 2.4GHz, 900MHz and 868MHz. Each ZIGBEE module is connected to a PC via a Serial to USB Convertor for communication with MATLAB program. MATLAB has been used to encode the image data, and then transmit data to the router nodes [4]. At first, the image at coordinator node is divided into small packets and then these packets are transmitted. The router node receives the image data, in form of packets and then MATLAB is used to decode the image data. This image data is used to generate a 3-D image. Secondly, captured real-time stereo images are segmented using Darwinian Particle Swarm Optimization [2]. The Segmented images are given to the disparity algorithm to estimate the depth values. The coordinator node of ZIGBEE module sends this depth data directly. Another router node receives the depth data, which is then decoded and these decoded values are used to control the ROBOT. Block diagram of system implemented for wireless transmission is shown in Fig. 2.

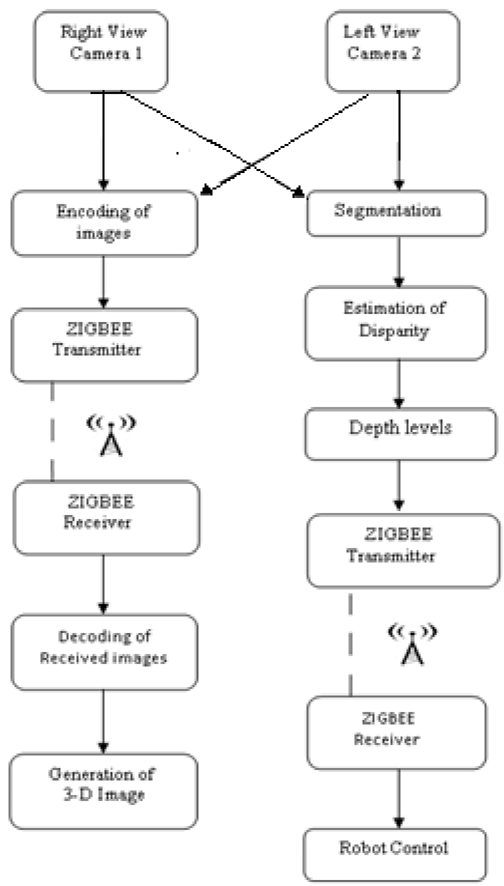

Figure 2. System used for wireless transmission.

III. ZIGBEE

The ZIGBEE Alliance [6] is a consortium of over 90 companies that is developing a wireless network standard for commercial and residential control and automation applications. Wireless communication standards focusing on high speed and long range have been applied for cellular and local area data networks. Transmission of images by using Bluetooth network had been tried, but Bluetooth-based networks can cover the distance up to 10m, while ZIGBEE based networks can be used up to 100m. Bluetooth takes three seconds to join a network while ZIGBEE joins a network in 30 milliseconds [6].

The Alliance has recently released its specifications for a low data rate on wireless network. The design goals for the network have been driven by the need for a Machine-to-Machine (M2M) communication of small simple control packet and sensor data, and a desire to keep the cost of wireless transceivers to a minimum. ZIGBEE is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power wireless M2M networks, and it currently uses IEEE 802.15.4 MAC and PHY layers, as shown in Fig. 3 [5]. ZIGBEE generally uses a single channel for data transmission. A ZIGBEE module has three nodes, namely, coordinator node, a router node, and an end device node. End-device nodes communicate with each other through a coordinator node. A coordinator node is responsible for starting the network and for choosing certain key network parameters. The end-device nodes not only communicate with the coordinator node but also communicate with every router node. However, the router nodes processing a routing function cannot directly communicate with each other; they can communicate only with coordinator [5]. ZIGBEE network has three modes of transmission, namely, AT (by default), API and API with escape character. In the AT (Transparent Mode), data coming into the Data IN (DIN) pin is directly transmitted over-the-air to the intended receiving radios without any modification. API (Application Programming Interface) mode is a frame-based method for sending and receiving data to and from a serial UART (Universal asynchronous receiver/transmitter). API with escape character is an extended version of API which is used to prevent data loss in noisy environments. Both API and API with escape character are used to insure secure communication. In this setup AT (Transparent Mode**)** mode of transmission has been used as it is easy to configure ZIGBEE in this mode and currently secure communication is not considered in the present prototype.

TABLE I. HARDWARE SPECIFICATIONS

ZIGBEE module

- Operating frequency: 2.4GHz.
- Low cost wireless module.
- Data rate: 250Kbps.
- Operating range: 100ft (30m).

Wireless camera

- Connection Type – Corded USB.
- USB Type –High Speed USB 2.0.

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A. ZIGBEE Protocol

ZIGBEE is best described by referring to the 7-layers of the OSI model [8] for layered communication systems. The Alliance specifies the bottom three layers (Physical, Data Link, and Network), as well as Application Programming Interface (API) that allows end developers the ability to design custom applications that uses the services provided by the lower layers. Fig. 3 shows the architecture adopted by the ZIGBEE alliance [5].

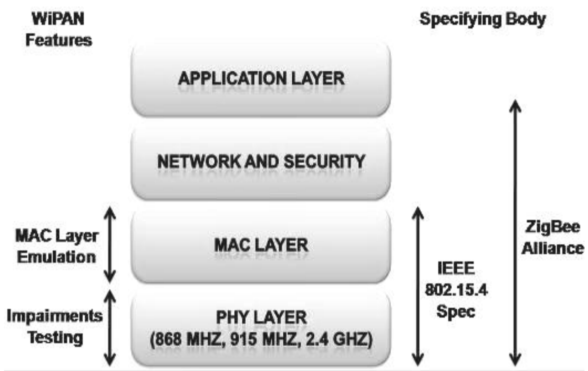

Figure 3. ZIGBEE stack [5].

B. Limitations of ZIGBEE protocol

The 2.4GHz band provides the highest bit rate of 50 Kbps in IEEE 802.15.4 PHY specification. The physical layer supports transfer of only small sized packets which is limited to 127 bytes. Due to overhead at the network, each packet may contain at most 89 bytes for application data. This leads to loss of data during transmission. Therefore, there is a need for fragmentation of bit streams larger than 89 bytes. A flow-control mechanism is also needed to acknowledge and request retransmission of missing fragments above the network layer [5].

C. Transmission of image through ZIGBEE

If a large number of pixel values of an image are transmitted by using ZIGBEE then there is a loss of data in an abrupt manner at the receiving end. For this, the data needs to be fragmented. In this case an image of size 115 X 132 was transmitted using ZIGBEE. An image of size 115 X 132 has 15180 pixel values. The image is fragmented into small packets and each packet contains approximately 2000 pixel values. For a complete transmission of the image, eight packets are required. Since each packet is transmitted separately, there is an increase in time taken for transmission of the complete image.

D. Control of ROBOT by using depth information

The depth levels estimated from disparity data are transmitted through ZIGBEE module. The depth levels received by the receiver are used to control the ROBOT. Binary data for a specific time delay (depending upon the depth levels) is sent from parallel port of the computer to ROBOT, according to which it covers a specific distance. The data given to a parallel port from MATLAB at data pins (D4-D7) goes to the octal buffer IC 74LS244 through db-25 which is used to reduce DC loading. The output of the 74LS244 IC is fed to the motor driver IC L239D which controls the rotation of the motor, which in turn causes the movement of ROBOT. The complete control action of ROBOT is shown in Fig. 4.

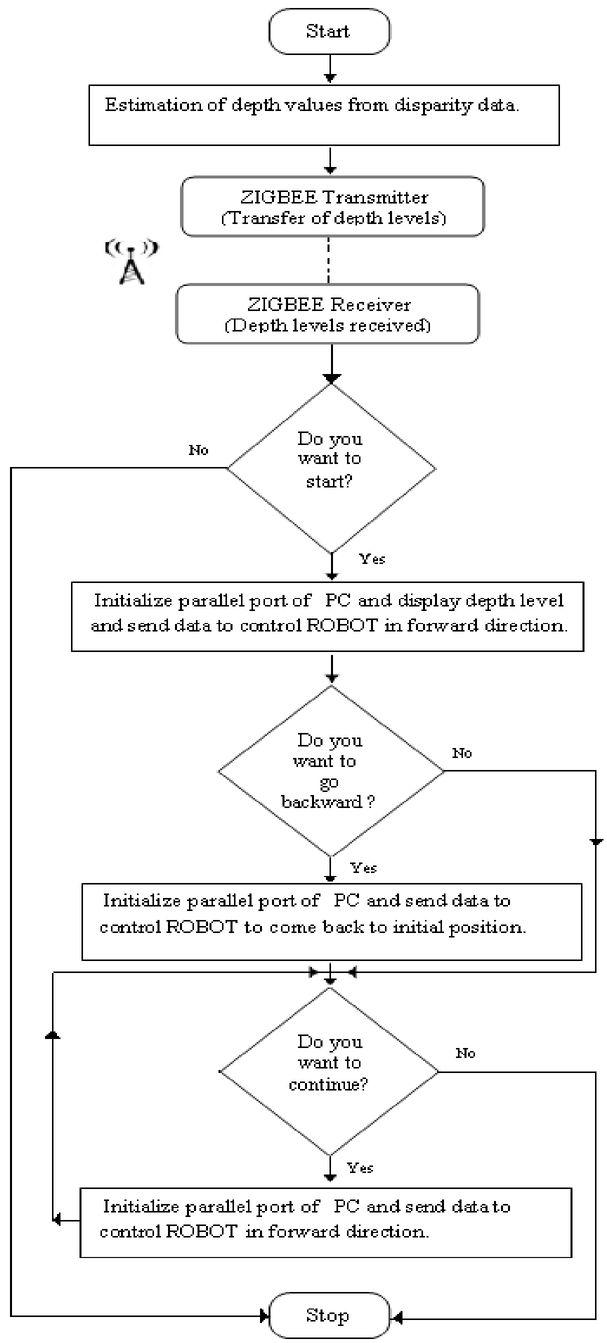

Figure 4. Flowchart for ROBOT control.

IV. RESULTS

The testing of the present setup was done on several images from Middlebury data set [4]. One of the image pair, which was transmitted using ZIGBEE and received at the receiver ZIGBEE module, is shown in Fig. 5 and Fig. 6.

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Figure 5. Left and Right view of images transmitted.

Figure 6.Left and Right view of images received.

Figure 7. Reconstructed 3-D image.

The time taken to send a complete image was about 60 seconds; but, as there was loss of data, this image was split into eight packets. Therefore, the time taken for transmission of each packet of image data was 30.2857 seconds. Thus, the time taken to transfer the image of size 115 X 132 was 2.42 minutes. If there is loss of data, retransmission is necessary. It was observed that when there was a need for retransmission of packets, the maximum time taken to transfer a complete image was found to be 3.52 minutes. In this case, the ROBOT control mechanism is not synchronized with the type of image, but it moves forward depending upon the number of depth levels in an image. However, in the future, it may be synchronized with real-time industrial control applications. A reconstructed 3-D image at the receiver side is shown in Fig. 7.

Six different images from Middlebury data set [4] were transmitted and received at the receiver. The Peak Signal-to-Noise Ratio (PSNR) values of received images in db were plotted and are shown in Fig. 8.

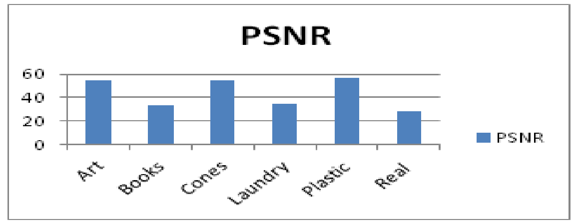

Figure 8. PSNR values obtained for images received at ZIGBEE receiver.

V. CONCLUSION AND FUTURE WORK

A 3-D image was generated at the receiver end. It was observed that there is always a compromise between PSNR and time taken to transmit the image. The time taken for transmitting an image can be reduced by implementing a mesh or star topologies using a set of ZIGBEE modules, which may give rise to loss of data. The transmission time can also be reduced by using image compression techniques at the transmitting end but this will affect the PSNR of generated stereo images, which, in turn, will affect estimation of disparity. In other words, transmission of compressed images obtained by using compression techniques lead to lossy received images. This is due to the fact that transmission of decimal point values requires more time as these data has to be converted into string format which further increases the size of data. In the future, the above algorithms can be implemented on advance microprocessors such as, ARM9 [9] which will facilitate system on chip wireless transmission modules.

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