Asian Journal of Information Technology 15 (6): 1073-1078, 2016
ISSN: 1682-3915

Design and Construction of Face Tracking Servent Robot Using Zig Bee in In-Door Environments

[1]K. Arutselvan and [2]C. Manoharan
[1]Paavai College of Engineering,
[2]Sri Shanmugha College of Engineering and Technology, Tamil Nadu, India

Abstract: This study describes the embedded system for servant robot using Zig bee communication and face tracking using MATLAB. The robot has designed in such a way that it look like human. The robot named JANDE has camera on his head for visual tracking of human faces. The camera detects the face details in a MATLAB code running on PC. Then, according to result, the characters first sent to the microcontroller which resides at the robotic side using Zig bee transceiver. This robot also has a battery powered microcontroller unit which give control signals to various actuators. The robotic movement is controlled remotely from the local system by using the characters via Zig bee. The Zig bee (IEEE 802.15.4) supports a frequency range of 2.4GHZ, 9600 baud rate with 256 Kb of flash memory. It supports the range of 400m in open-air, line-of-sight, outdoor environment. That is the robot can move and reach to the high destiny region and also serving human.

Key words: Face tracking, JANDE, CAM shift algorithm, Zig bee, IEEE

INTRODUCTION

The JANDE robot is an autonomous servant robot. The robot's design specifications may vary according to the various applications. A low cost embedded system has designed to perform specific control functions within a larger system, often with temporal constraints. It is embedded as part of a complete device often including hardware and mechanical parts. Key characteristic, however is being dedicated to handle a particular task. Since, the embedded system is dedicated to specific tasks, design engineers can optimize, it to reduce the size and cost of the product and increase their reliability and performance having a interaction between humans and robots has become one of the important scenario in many different vision based topics and robotic communities. Since, the utilizing of robots has significant increased in human life autonomous behavior is defined to have intelligent systems for robots and lots of researches in this area. Indeed, real-time responses will aid human to interact with robots naturally and at the same time, increase the application of using machine in everyday life. In this study, an optimized algorithm for JANDE in order to have a real-time multi-person tracking with humans has been designed. The main aspect of the proposed method is researching in real-time. In fact, she might be useless if she cannot have a real-time act and react with human. So, the first factor that is considered in all investigated methods in this survey is being real-time.

MATERIALS AND METHODS

Proposed system: The proposed robot JANDE is easy to design and implement both in hardware and software aspects. It uses less complex microcontroller, high sensitivity AV camera and Zig bee to support reliable and robust wireless communication netresearch.The PIC16f877a microcontroller is embedded with embedded C program which processes the received data through Zig bee and provides communication to actuators using driver circuits. The JANDE robot is a battery powered and controlled remotely through MATLAB running on PC. At the local system, the front end is program which is simple coding and easy to understand. The existing system does not support live tracking but our system provides live face tracking to control JANDE. This intelligent robot is mainly useful in office and home which detects the alive human in the need and provide assistance.

Robot design process: The embedded system design process and has five major levels of abstraction. At each and every level, there are three tasks like analyze, refine and verify were performed to ensure the system requirements and specifications. There are two ways in the design methodology and are Top-down and Bottom-up method (Galatsis *et al*., 2000) and this research adopts the Top down method. Figure 1 shows methodology.

Requirements: The requirements must of course capture the basic needs of the user and of the embedded system

Corresponding Author: K. Arutselvan, Paavai College of Engineering, Tamil Nadu, India

Table 1: Requirement list

Requirement	Description
Name	JANDE
Type	Humanoid
Purpose	ROBOT monitors the environment; provide control signal from remote system. Raises particular actions for different critical situations for serving purpose
Parts	Head, two arms, four legs with wheels
Input	Facial features from camera, characters from MATLAB on PC
Output	Face detection and tracking, Remote PC display, Relays, LEDs
Functions	Depending on the movement of face the MATLAB program provide control message to serial communication and switch ON/OFF the relays and drivers for Robotic wheel movement and hand. Perform real-time video streaming at local system
Manufacturing cost	Approximately 370 USD
Power	12v, 9 Amps
Size	Height-3.5 ft width-2 ft
Weight	5.300 kgs

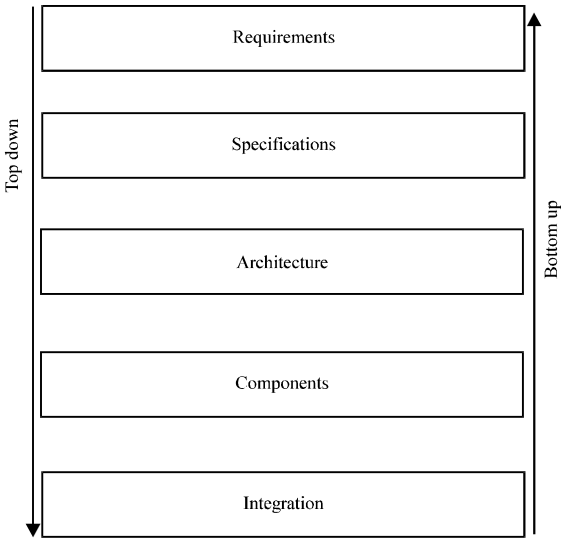

Fig. 1: Design process

but functional requirements is often not sufficient. An informal description from the user was gathered and is known as basic objectives then these requirements are refined into a specification that contains enough information to begin the system architecture. Requirements may be functional or non-functional.

Functional requirements:

- Detecting faces
- Tracking faces
- Giving correct control characters through Zig bee

Typical non-functional requirements are cost, performance, power and physical size and weight and these requirements are given in the requirement form shown in Table 1.

Specifications: The specification says only what the system does and does not specify how to implement. In

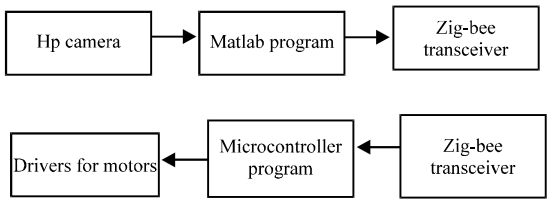

Fig. 2: JANDE architecture

this proposed research, the specification of the system includes:

- Character received from Zig bee (100M)
- MATLAB algorithm
- JANDE Display
- Face tracking
- Characters from PC

Architecture The architecture is a process that how the system implements the functions which are illustrated in the specification level. The system architecture is further refined in to hardware and software architecture which describes the components that needed to build the entire system. The architectural descriptions must be designed to satisfy both functional and non-functional requirements. Figure 2 shows the hardware module in which the MATLAB send the signals to the JANDE through Zig bee, the controller process the data and send the control signals to the actuators and switches the relay according to the conditions for ON or OFF the Motors (Ramya *et al*., 2012). The Zig bee connected to the microcontroller will receive the character from transceiver at the local system. Zig bee at the local system gives character that given by MATLAB program according to the face movements, the data and displays the output. Figure 2 shows architecture of the robot.

The components in general include both designing the hardware and software components. The components used in this research are discussed. The basic components involved in this research are PIC16f877a

Fig. 3: JANDE head

Microcontroller, Driver L293D, HP camera, Relays, DC Motors, Zig bee module. The system integration is not simply plugging everything together but also finding the bug at right time in this stage. While testing the system, it is difficult to find why things are not researching properly and hence, it is hard to find and fix the bug. Due to limited facility at the target system have to go to host system each and every time for testing. As for as, the embedded system concern the system integration is a challenging task.

JANDE descriptions: CAMshift is called continuously adaptive mean shift based on the mean shift algorithm (Bin and Kang, 2007). CAMshift uses the Hue channel to trace objects since by using the Hue channel based on HSV color model, objects with different colors can be recognized. Based on the color information, CAMshift tracks objects faster and consumes relatively little CPU resources. Lower computing resource requirement enable CAMshift to become a one of real-time face tracking algorithms. The HP camera is used as Robotic vision that is shown in Fig. 3. The PIC16f877A microcontroller is used in this research which is an 16-bit microcontroller and has 1MB of Flash memory and 256 bytes of RAM. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. The PIC16f877A is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications. It has five ports designated as A, B, C, D and E. All these ports are 16-bit bi-directional ports; they can be used as both input and Output ports.

It is compatible with MCS-51™ products and having the following features like 4 K Bytes of in-system reprogrammable Flash Memory, Endurance: 1,000 Write/Erase Cycles, fully static operation: 0 Hz-24 MHz,

Fig. 4: Zig bee module: a) Interface RS232 with Zig bee at PC; b) Interface Zig bee at robot side

Three-Level Program Memory Lock, 128x8-Bit Internal RAM, 32 Programmable I/O Lines, Two 16-Bit Timer/Counters.

The CC2530 Zig bee module used in this research is a true system-on-chip solution tailored for IEEE 802.15.4 and is suitable for the low power applications. The CC 2530 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced PIC MCU, in-system programmable flash memory, 8 KB RAM. The CC 2530 comes in four different flash versions: CC 2530 F32/64/128/256 with 32/64/128/256 KB of flash memory, respectively. This project uses 256 K flash memory. Short transition times between operating modes further ensures low energy consumption (Birk and Carpin, 2006). The range of CC 2530 highly depends on antenna design, product enclosure, physical environment including obstructions obstacles environment like temperature and humidity of the air. It is able to achieve 99% packet transmission success with 400 m in open-air, line-of-sight, outdoor environment. The Zig bee module is shown in Fig. 4.

The Zig bee module's transmitter and receiver are connected with port P3.0/RXD at pin number 10 and P3. 1/TXD at pin 11 of the AT89C51 microcontroller. The communication between robot and the local system is a wireless communication using Zig bee. Figure 4a shows interfacing RS232 with Zig bee at local system and Fig. 4b shows interfacing Zig bee at robot side.

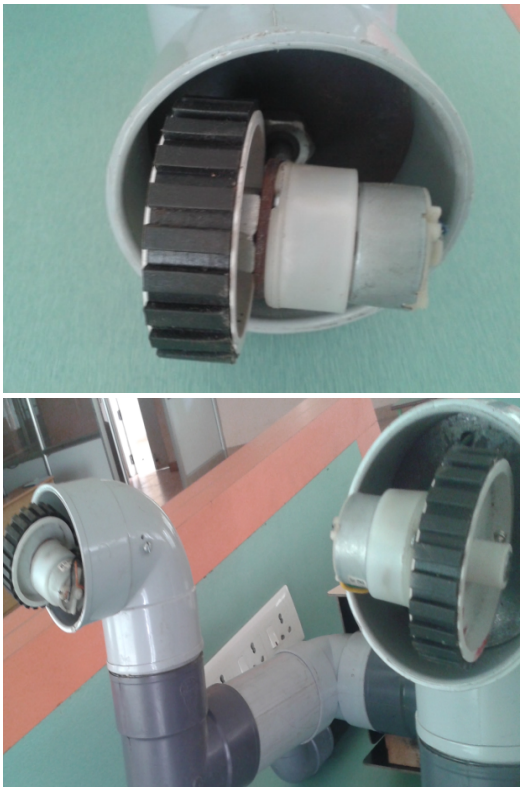

Fig. 5: DC motor is connected with JANDE wheel

A 12V DC geared motors is very easy to use and available in standard size. Nut and threads on shaft is easily connected and internal threaded shaft are easily connecting, it to wheel.

The 12VDC geared motor is used in variety of robotics applications which is available in wide range of RPM and Torque. Figure 5 shows how the DC motor is connected with JANDE wheel.

Camshift algorithm: First select the original search window and making the window cover the entire tracing target. Then, take sampling of the value in H channel in the window which results the tone histogram of the target. In the tracing process, we can determine the probability of whether the pixel is the target pixel by comparing the pixel in the image with the histogram. The other area besides the image process area is seen as the value of probability of zero. Through, the above processing, the video image turns to be target color probability distribution, also called target color projection drawing. For the convenience of displaying.

We transform the projection drawing to grey projection drawing of 8 bits, the pixels value of probability one is 255, the pixels value of probability zero is 0 and other pixels value transform to the correspond gray value. By doing so in the grey projection drawing, the brighter the pixel is the more probability, it is the target pixel. The specific computational step is discussed below.

First step: Initializing a search window W in the color probability distribution, the window size is S.

Second step: Using mean shift algorithm to converge the search window; using formulas to calculate the barycentre of the search window in the 2D probability distribution image and readjust the center of search window to the calculated bary center; repeating this process, until convergence.

Third step: Resetting the search window size S and calculate and trace the output parameters. For the 2D color probability distribution image, zeroth moment represents the traced target acreage in the image and because the color probability distribution image is 256 pieces of quantization level grey image so the relation between the width of search window a and zeroth moment Z_{00} is:

$$\propto = 2\sqrt{\frac{z00}{256}} \tag{1}$$

Fourth step: Back to the second step and beginning the recycling of next frame. To the face tracing system, the oval modelling is similar to the human face so when outputting the tracing parameters of human face, described using the tracing results in the form of oval modelling. The oval modelling parameter includes long axis, short axis and direction angle of oval. Through, calculating the second moment of searching window, the long axis, short axis and directional angle of the traced target has been found. Calculating the second moment of searching window:

$$Z_{20} = \Sigma_x \Sigma_y X^2 p(x,y) \tag{2}$$

$$Z_{02} = \Sigma_x \Sigma_y y^2 p(x,y) \tag{3}$$

$$Z_{11} = \Sigma_x \Sigma_y xyp(x,y) \tag{4}$$

In Equation, p(x, y) is the pixel value of PDI image in the coordinate (x, y) which is also the color probability value of original pixel in that point. The variation range of x and y is the range of searching window:

$$a = (Z_{20}/Z_{00}) - x_c^2$$
$$b = 2((Z_{11}/Z_{00}) - x_c y_c)$$
$$a = (Z_{02}/Z_{00}) - Y_c^2$$

The length of target long axis and short axis in the image can be calculated by Eq. 5 and 6:

$$\lambda = \left(\sqrt{(a+c)+\sqrt{b2+(a-c)2}}\right)/2 \quad (5)$$

$$\omega = \left(\sqrt{(a+c)-\sqrt{b2+(a-c)2}}\right)/2 \quad (6)$$

Based on the above-mentioned steps, the calculated results is the target center and oval parameter of every frame. Portraying the area in the output image sequence which form a continuous tracing to the target.

RESULTS AND DISCUSSION

The prototype of the robot is shown in Fig. 6. The robot has four wheels which are used for moving backward, forward, left and right turns and two hands for giving things. The Zig bee at the robotic side is used for receiving data from PC (Cherubini *et al*, 2007). The proposed robot is a battery powered and compact system. The result is shown in Fig. 7. The result is acceptable but not accuracy. Affected by non-uniform light condition, the result becomes worse since, the light changes the color of the object. Moreover, the similar color background, hands and necks also lower the performance. The image in Fig. 7 is the version In the MATLAB by using the essential CAMshift idea to track faces. With some optimizations, the real-time tracking face based on CAMshift is feasible.

After face detected the whole system has been mounted on the servant robot. It will be controlled using PIC microcontroller. There are two modes. One will be manual mode the robot is operated using hyper terminal and ZIG-BEE. Another one automatic mode, in this control given by MATLAB based on face detection.

There are totally 11 DC motors are used in this project. Relays and motor drivers are used to convert the 5v signal coming from the PIC microcontroller to 12v for operating motors.

Table 2 and 3 show the experimental result with the performance on the detection rate, false alarm rate and average processing time. From these result, our proposed

Fig. 6: JANDE robot

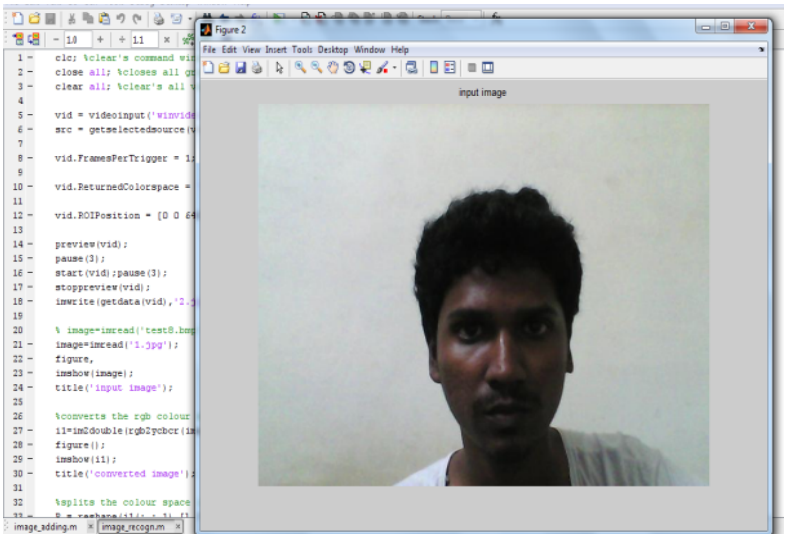

Fig. 7: Face tracking

Table 2: Face detection data

Method	Face number	Correct	Misses	False alarms	Precision (%)
Skin color	200	176	24	14	88
Adaboost	200	170	30	24	85
Proposed method	200	188	12	8	94

Table 3: Processing time

Methods	Only adaboost (ms)	Proposed method (ms)	Improved efficiency(%)
Single face sequence	19.72	10.84	45.03
Multiface sequence 1	24.64	9.81	60.19
Multiface sequence 2	20.05	8.41	58055.00

method can robustly detect human faces with reduced computational cost in different scale, various poses and illumination condition. Furthermore, the proposed method could detect both dark skin-tone and bright skin-tone with high detection rate. In manual mode, characters are used as controls:

- F-moving forward
- H-Head rotation
- G-Giving in right hand
- R-moving Reverse
- C-Circleing 360 deg
- A-Automatic mode

CONCLUSION

The proposed robot JANDE can be used in home, office, industries, research and educational institutions and so on. The robotic movement is controlled remotely through the local system.

The user (human or animal) entered into the room/range is detected through the camera, the sensed parameters were sent to the local system through MATLAB program that is CAMshift algorithm which is used to detect and track the faces. After detecting features, it calculates and give desired character in order to control robot that character is transferred through Zig bee which presented at both the ends that is at the robot and at the local system. And, at the same time visual is displayed in LCD display accordingly. Camera send's the robotic environment information to the local system. The video streaming is simultaneously done at only local system. This system can be used where ever the assistance and help required. In future, this research may be enhanced in such a way that whenever a picture is captured then a system uploads online through online internet the user can operate JANDE and it can immediately send an email about the picture. And also, WI-FI may be used to increase the communication distance between the robots and with the local system or otherwise local system can be connected to online where JANDE uploads tracked faces so that it will research and move independent without setup that fixed static at a place.

REFERENCES

Bin, A.S.K. and L.Y. Kang, 2007. Face detection and tracking utilizing enhanced camshift model. Int. J. Innov. Comput. Inform. Control, 3: 597-608.

Birk, A and S. Carpin, 2006. Rescue robotics-a crucial milestone on the road to autonomous systems. Adv. Robot. J., 20: 595-605.

Cherubini, A., G. Oriolo, F. Macri, F. Aloise, F. Babiloni, F. Cincotti and D. Mattia, 2007. Development of a multimode navigation system for an assistive robotics project. Proceedings of the IEEE International Conference on Robotics and Automation, April 10-14, 2007, Rome, Italy, pp: 2336-2342.

Galatsis, K., W. Wlodarski, Y.X. Li and K. Kalantar-Zadeh, 2000. Vehicle cabin air quality monitor using gas sensors for improved safety. Proceedings Conference on Optoelectronic and Microelectronic Materials and Devices, December 6-8, 2000, Bundoora, Victoria, Australia, pp: 65-68.

Ramya, V., B. Palaniappan, K. Karthick and S. Prasad, 2012. Embedded system for vehicle cabin toxic gas detection and alerting. Procedia Eng., 30: 869-873.