Some implementation of live video transmission and motion tracking

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***Abstract*— Video transmission is one of the important part in information technology. But it's related on capability of network. So we experimented to decrease data size and transmitted by bit rate algorithm on own designed mobile robot. Mobile robots now widely used various security and surveillance applications. For automatic mobile robot with front-camera, one of the main issues is navigation and detection of living bodies using the camera. Based on detected movement, robot will start tracking the object and shooting the camera. Video is transmitted to user web page through the WIFI network for remote monitoring of indoor environment. The remote place owner will receive these real video and will be possible to control the robot through internet for observe view of the surroundings. Also we use the variable bit rate algorithm reduces overflow of the network and increases stability of the system for wireless video transmission technology.**

Keywords—mobile robot, video streaming, remote control, teach/replay method, variable bit rate

I. Introduction

For various security and surveillance system, one of the important applications is remote environmental monitoring that is live video transmission using WIFI network. But most of them are using surveillance cameras already mounted but they cover very limited areas. The cameras already mounted at a fixed position, is not of much use as we cannot change the camera view in real time [1].

Mobile robots with surveillance camera now widely used various security and surveillance applications. Because the robot is able to move anywhere for observe view of the surroundings [2]. Thus in this paper, we introduce development of robot system using wireless video communication for monitoring indoor environment.

The system utilizes a) wireless video transmission technology; b) a navigation system featuring "teach and replay method" for automatic detection and tracking; c) ARM Cortex 9 based board with embedded Linux, Arduino board, bluetooth and OpenCV for remote control and image processing, respectively.

This type of surveillance robot system represents a significant advance towards self-learning robot systems in this paper. The proposed system is used teach/replay phases, developed by Zhichao Chen and Stanley T. Birchfield in 2006 [3], to simplify the challenges of autonomous indoor navigation and mapping for a mobile robot equipped a single camera. In the teaching phase, an operator manually controls the mobile robot through the desired path to gather training data. Next, in the replay phase, the robot automatically proceeds to compare training data which is same initial location as that of the teaching phase [4]. This approach is convenient solution for the mobile robots.

In this paper the wireless technology consider for integrate robot and users to the system network. Last decades, wireless communication has increased to a number of available devices and applications are becoming more sensible by year. Thus, the wireless technology is used in many mobile robot platforms to communicate with server computers, machine interfaces or other robots [5, 6].

The wireless network is used to stream video to control unit. Therefore video coding, video compression and video transmission by wireless technology are introduced [7, 8, 9].

However, it may cause overflow in the network. Variable bit rate algorithm reduces overflow of the network and increases stability of the system. In this work, we implemented the proposed algorithm that reduce overflow of the network for transmit video streams by WIFI.

This paper is organized as follows. First, we introduce wireless video transmission technology and teach and replay method which are important part of our system. In section 3 we introduce the design of mobile service robot system. The implementation of the developed system is presented in section 4. The section 5 is the conclusion of the work.

II. Related works

A. Wireless video transmission technology

Video streaming size is relatively large to be communicated via wireless network. Therefore, mobile robot taken video data has to be compressed before it is transmitted to the control unit. Thus we focus on how to decrease data size for transmit in a robot vision system. Any simple video compression algorithm consists of these blocks in Fig. 1, such as MPEG, JPEG, or H264/AVC decomposes it into several frames.

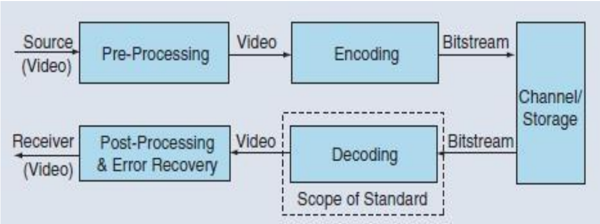

Fig. 1. Scope of video coding standardization

Video compression can be divided into pixel/frame based (e.g MPEG-1, MPEG-2) and object based (e.g MPEG-4, H264) [10].

In this project, we use H264/AVC [10], the latest standard for video coding that was developed by ISO/IEC Moving Picture Experts Group and the ITU-T Video Coding Experts Group.

Thomas Wiegand et al. shows us H.264/AVC [7] that is an advanced standard in video coding technology, such as coding efficiency enhancement and flexibility for effective use over a broad variety of network types and application domains. Its video coding layer-VCL design is based block-based hybrid video coding concepts, but there are some advances mentioned below than others. We thus summarize some of the important differences [7, 10]:

• Enhanced motion prediction capability using multiple frames;

• Use of a small block-size exact-match transform;

• Adaptive in-loop de-blocking filter;

• Enhanced adaptive entropy coding methods.

H264/AVC when used definitely together, it is allowed for bit savings approximately a 50% compared to prior standards.

On the other concept is wireless communication. For last decade, there is new service area called video over wireless [7, 8, 9]. It means digital video compression file transmitted by digital wireless communication.

Wireless communication includes many systems and applications, such as wireless LANs, satellite system, voice, video etc. One point is different systems have different requirements [11]. Therefrom real-time video systems have high data rate required but it spend much time for transmit by wireless network [7, 10].

We probed the transmission of a single video stream over by 802.11a wireless link.

B. Teach and replay method

In this section, we present a simple technique that is an implementation of the Kanade-Lucas-Tomasi (KLT) feature tracker approach which consists of teaching and replay phases. KLT algorithm is presented in Eq.1, which computes the displacement $d=[d_x-d_y]^T$ minimizes the sum of the squared differences between consecutive image frames I and J:

$$\iint [I(x-d/2)-J(x+d/2)]^2 \, dx, \qquad (1)$$

W - a window of pixels around the feature point and $x=[xy]^T$ is a pixel in the image [4].

In the teaching phase, a person manually navigates the robot by the path which is divided into a number of segments to collect training. Feature points are automatically detected in the each segment and these are stored in a database for use next phase.

In the replay phase, the robot is placed in same destination when begins in the teaching mode. The robot retrieves sequentially the saving segments. At the first of each segment, coherence is defined between feature points in the current image. Then, by the feature points are tracked overall the incoming images till the last teaching image of the segment named by milestone. All of feature coordinates are compared with it.

The main feature of this approach is the robot without any calibration, it is able to follow the path by only feature coordinates.

[4] is a simple control algorithm. For every successfully tracked feature point i, we compare the x-coordinate (u_i^t) of the point in the current image with the coordinate (u_i^d) of its corresponding point in the destination image:

- if $u_i^t>0$ and $u_i^d<0$, then turn right
- else if $u_i^t<0$ and $u_i^d>0$, then turn left
- else if $u_i^t>0$ and $u_i^t>u_i^d$, then turn right
- else if $u_i^t<0$ and $u_i^t<u_i^d$, then turn left
- else do not turn

Finally, successfully guiding the robot, it is necessary to have number of feature points diffused over the image. If $N_R-N_L>0$, then turn right; else if $N_L-N_R>0$, then turn left; else do not turn anywhere. In this situation each point votes for “turn right”, “turn left” or “do not turn” [3, 4].

III. DESIGN OF MOBILE SURVEILLANCE ROBOT SYSTEM

We designed the mobile surveillance robot with front and back-camera that moves into the visible coverage of camera in indoor environment. When detects movement the around of robot, the robot can track the object and shoot the camera.

It also transmits the photo and video through wireless communication.

The mobile surveillance robot system consist mobile robot, main control unit and WIFI router, which are connected to one wireless network. Fig. 2 shows main diagram of the system.

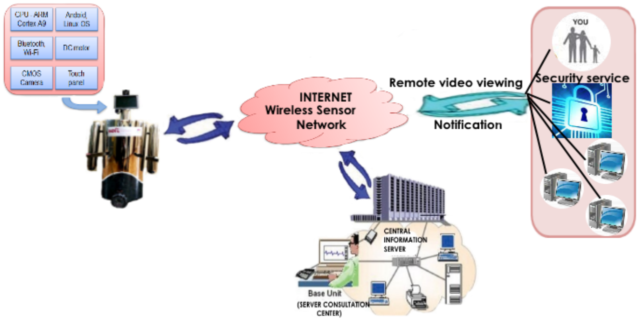

Fig. 2. The main diagram of the system

In the Fig. 3, the control of robot is composed two parts that main board based on Exonys4412 module and control board based on Arduino in the Fig 3.

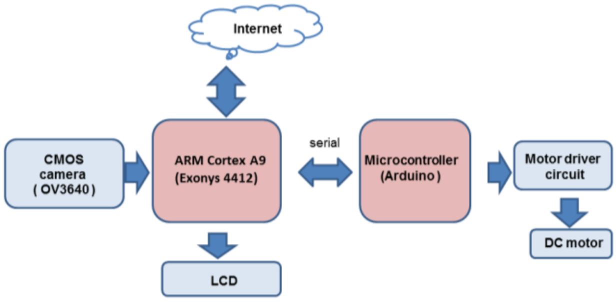

Fig. 3. The block diagram of the robot control

In the Fig. 4, we designed a main board of our robot based on exonys4412 module with ARM Cortex A9 processor. This main board is used for image processing, video playing, and sending the video to the user through the internet.

Our designed embedded board performance:

- CPU - ARM Cortex A9 Quad core 1.7GHz,
- Memory - RAM DDR3 2GB,
- Flash EMMC 16GB,
- External Interfaces - USB,
- HDMI, External mini SD card
- Built in cameras - Front 3M,
- Rear 5M pixels cameras
- OS - Android 4.4 KitKat
- Display - 10.1" IPS Wide 1280 x 800 capacitive touch panel
- Communication interfaces - Wi-Fi - 802.11b/g/n,
- Bluetooth (4.0)
- The block diagram of the robot control

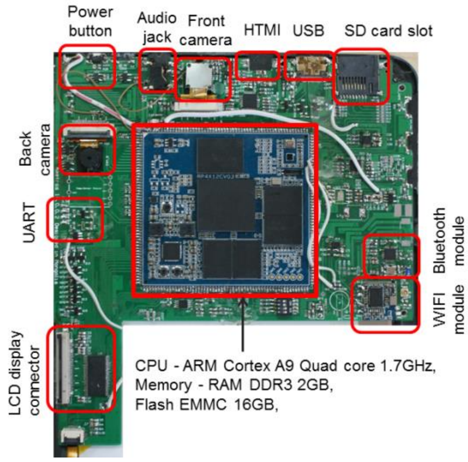

Fig. 4. Embedded main board

The control board based on Arduino with atmega128 microcontroller is used for controlling mobile robot with three omnidirectional wheels.

We used a serial interface for communication between Exonys4412 (ARM) and Arduino (Microcontroller). Motor driving circuits are used for operating motors. LCD screen is used for the testing purpose i.e. to test the communication between hand unit and robotic unit and to play the video since shooting in the SD card.

IV. Implementation

The mobile robot has ARM Cortex 9 based development board with embedded Android operating system, which makes it possible to run OpenCV based CMOS camera server program, written in python language. Furthermore, it enables transmitting video stream to main controlling unit via Wi-Fi network.

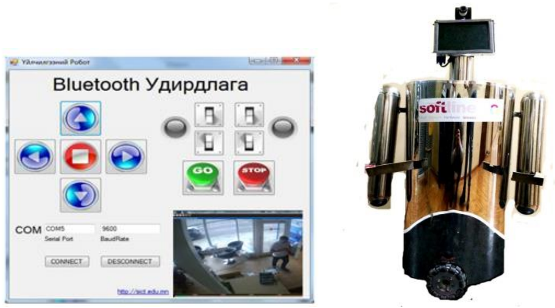

Fig. 5. Mobile robot with omnidirectional three wheel and it's manual control application's graphical user interface.

Main controlling unit is a personal computer running OpenCV based robot navigation program on it, written in python language. Robot navigation program works under teach and replay method which is based on Kanade-Lucas-Tomasi (KLT) feature tracker. After processing received data, the main controlling unit transmits specific commands to robot's driver part via serial connection.

The manual control is combined with android and windows application which shows video stream on it and controls the robot depending on the pressed button via bluetooth while automatic control is fully implemented our design of mobile service robot system.

Fig. 5 shows experiment of KLT feature tracker algorithm in replay phase.

a)

b)

Fig. 6. Experiment of KLT feature tracker algorithm

Fig. 5 b) shows previously stored feature data. Fig. 5 a) shows feature point tracking result. In this figure, red circles indicates similar features, green circles indicates feature points shifted to the left, blue circles indicates feature points shifted to the left.

During automatic operation, variable bit rate algorithm decently works and streams video to the network. However, the teach and replay method was not fully functional in noisy background.

V. Conclusion

The mobile service robot development is one of the promising study in the field. In this research work, we developed design of mobile service robot system using wireless video communication for indoor environment. This kind of robots are very useful in many purpose such as security and surveillance system, hash-slinger robot, promotion robot, nurse assistant robot and carrier robot etc. It makes possible to integrate multiple robots to the system using wireless network. However, it may cause overflow in the network. Variable bit rate algorithm reduces overflow of the network and increases stability of the system. For further development for the system, it's highly needed to implement advanced image processing methods for unstable environment. Example: Our robotic system can also be used in finding people during disasters such as earthquakes, collapsing or burning building and also in the mining fields etc.

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