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Development of Data Transmission and Information Extraction Algorithm for Mobile Robot

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ABSTRACT

This paper presents the data transmission and information extraction algorithm. The presented algorithm is implemented on the robotic platform available in the Mechatronics laboratory in the college department. The aim of this algorithm is to transfer, monitor and record audio and video through wireless network accurately and precisely for monitoring applications like patient monitoring in hospitals, security system, traffic monitoring etc. The algorithm, developed, overcomes the limited bandwidth problem of the video transmission by reducing the size of video by applying H.264 video compression algorithm. The algorithm is simulated using Visual Studio 2010 with Open-CV library. A Logitech C920 HD pro camera is used for high definition video capturing. The video capturing is done by defining the frame length, width, frame rate and the FOURCC code. After capturing the video it is saved by applying the H.264 video compression algorithm and with the help of Open-CV library in Visual C++. After compression, the video is transmitted to another system through Wi-Fi by using Dynamic Host Configuration Protocol (DHCP) server and the code written with the help of Python. Finally, the quality of the video transferred is assessed by determining the Peak Signal to Noise Ratio (PSNR) and Mean Squire Error (MSE) values. This algorithm can be implemented in places such as hospitals for sequential monitoring of patient conditions in future to reduce the workload of nurses. Also the night vision cameras will give more efficiency to the system.

Keywords— **Data transmission, H.264, Mobile Robot, Open-CV library**

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I. INTRODUCTION

In the current scenario, the need of mobile robot is essential for various monitoring applications like surveillance systems, traffic analysis, public safety, wildlife tracking and environment/weather monitoring etc. The wireless mobile robot will be helpful for human operators in difficult physical or environmental conditions such as mines. Nowadays, mobile robots are becoming an essential part in our day-to-day life. The vast amount of researches are going in the field of robotics to make the robots autonomous and human friendly. Each mobile robots should have a communication system to become human friendly.

Communication system consist of camera module and transmission protocol like WiFi. To develop data transmission protocol we need to analyse the awailablity of resources. In the mobile robot platform available at the Mechatronics laboratory at the college. It consit of an Atom Pc and a Logitec C-920 HD Pro camera module and a WiFi system. To design the system using these resources, the data should be transferred first. The transferred data should be considerred as 30s video that captures inreal time. Consider video as the huge amount of data to be transmitted.Low network bandwidth results in large delay in video delivery and lossy network channels lead to packet losses also.Processing and transmission of large amountof video data at each wireless node is challenging. So, the compression standards and algorithms will have a great role in processing these data [1].

The aim of this project is to design and implement the data transmission algorithm for mobile robot. So, it should be fullfilled through the objectives; select the best suitable video compression standard to reduce the file size without effecting the quality, record and transmit the video file using the mobile robot and analyse the quality of video transmission with or without different video compression standards, find Mean Square Error(MSE) and Peak Signal to Noise Ratio(PSNR) to measure the quality.

II. RELATED WORK

Due to rapid increase in technology growth in the area of robotics, the research on the mobile robot has been raised tremendously. Many approaches were developed over the year for video transmission. In mobile robot, the communication system is normally designed with the real time video transmission. But,it is not suitable for the monitoring applications. So, at the time various researchers present their concept on Closed Circuit Television (CCTV) cameras in robotics field. The main problem arises in the CCTV system are huge amount of data, cost andlarge amount of memory requirement for storage[1-2].

Embedded Zerotree Wavelet (EZW) algorithm is used to produce the fully embedded bit stream and consistently produces compression results that are competitive with virtually all known compression algorithms on standard test images. It uses successive approximation quantization together with Zerotree coding to provide embedded bit stream for the picture. The four fundamental concepts that describes by EZW algorithm are presented below[10].

1. A discrete wavelet transform or hierarchical sub-band decomposition
2. Prediction of the absence of significant information across scales by exploiting the self-similarity inherent in images
3. Entropy-coded successive-approximation quantization
4. Universal lossless data compression which is achieved via adaptive arithmetic coding.

To reduce the hardware cost and the energy consumption of the sensor network, a Lapped Bi-orthogonal Transform (LBT)-based low complexity and low memory image compression algorithm is used. This compression algorithm substantially lowers the computational complexity and reduces the required memory while it still achieves required Peak Signal to Noise Ratio (PSNR) [4]. Efficient compression and transmission of images in a resource-constrained multi hop wireless network is studied by the authors and evolve two design alternatives for distributed image compression. It uses a combination of tiling of pictures, and load balancing by nodes rotation to achieve much longer system lifetime [5].

Context-based Image Transmission (CBIT) scheme is an approach to manage image transmission in which spatial regions are selected and prioritized for transmission. Visually informative data is received in a timely manner in this approch. The cross-layer control [3], the multiple descriptions coding, and multiple error resilience technologies have been adopted in the H.263 and MPEG-4. H.264/AVC (Advance Video Coding) represents a number of advances in standard video coding technology, in terms of both coding efficiency enhancement and flexibility for practical use of a broad variety of network types and application domains. Its Video Coding Layer (VCL) design is based on conventional block-based motion-compensated hybrid video coding concepts, but with some significant differences. So, it makes 50% bit rate savings when compared to previous standards [7-9].

From the review of different papers related to processing and transmission of a large amount of video data in wireless network, various video transmission and image compression schemes such as VBR transmission, LBT based image compression, distributed wavelet based Image Compression, Embedded Zerotree Wavelet Transform, and Image transfer using CBIT and codacs like MPEG-1, MPEG-2, H.264/AVC video codec are analyzed based on their compliance to WSN [4-7].

The content aware video coding technique presented by the authorsDalei Wu *et al.*gives the idea of monitoring with accuracy by separating the target and background part. The authors present the usage of background subtraction technique that can be used in monitoring purpose [2].

By analysing different techniques, H.264 have more advantages and it suits for implementing in robots. So, the H.264 is chosen as the compression algorithm should be followed in the development of data transmission algorithm.

III. METHODOLOGY

This section describes the implementation approach for data transmission of a mobile robotic platform available at the mechatronics laboratory of department of mechanical engineering,SCoE,Pune shown in figure 1. The purpose of this robot is to capture, record, transmit and monitor video in a constrained environment for different applications like monitoring, analysis etc.

Fig. 1 mobile robot platform

A) Problem Formulation

The figure 2 shown below will give the main tasks to be followed at each stages like video capture, video transfer and video monitoring. From these procedure, the methodology should be followed can be decided. The step-by-step procedure of proposed algorithm is summarized as follows:

1. Initialize camera
2. Assign *frame rate=23, frame size as 640 × 480*.
3. If camera detected and initialized, start capturing.
4. Apply H.264 video codac to compress the original video.

5. Store the video at the memory using Video writer class.

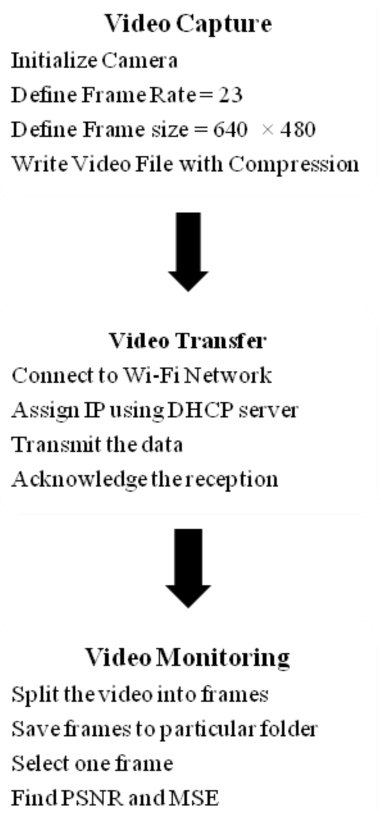

Fig 2. Problem formulation

A) The H.264 Video Codac

For the video capturing and transmission of the mobile robot platform shown in figure-2, a Logitech C-920 Pro HD camera is mounted and it is connected to the universal serial bus port of the Atom-PC. The Atom-PC is connected through Ethernet cable with Hydra board consist of ARM Cortex Processor.

Advantages of H.264/AVC are coding efficiency enhancement and flexibility for effective use over a broad variety of network types and application domains.

It differs from normal block coding in,

1. Enhanced motion-prediction capability
2. Use of a small block-size exact-match transform
3. Adaptive in-loop de-blocking filter
4. Enhanced entropy coding methods

H.264/AVC design is based primarily on a 4 x 4 transform. It consists of a VCL, which performs all the signal processing tasks and generates bit strings containing coded macro blocks.VCL design follows the block based hybrid video coding approach. A coded video sequence in H.264/AVC consists of a series of coded pictures. The Network Abstraction Layer (NAL) is designed by the authors to provide simplicity in the use of Video Coding Layer(VCL). NAL has the ability to map H.264/AVC VCL data to transport layers in byte-stream format. NAL units can be carried in data packets without start code prefixes.

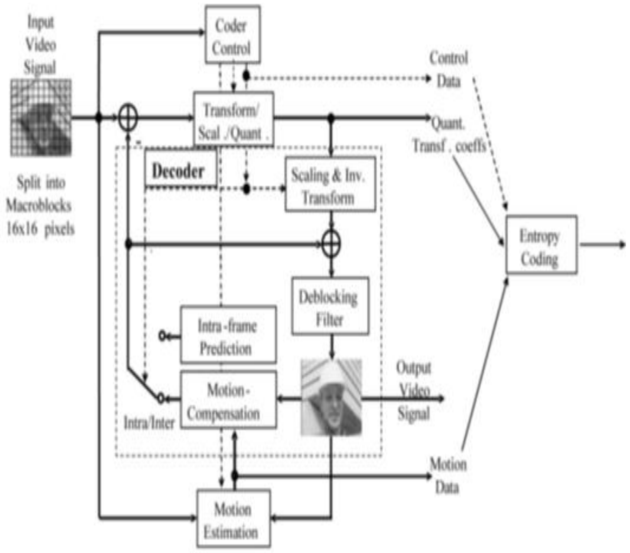

Fig 3. Basic coding structure for H.264/AVC for a macro-block [7]

B) Understanding about I-frames, P-frame and B-frames

Depending on the H.264 profile, different types of frames such as I-frames, P-frames and B-frames, may be used by an encoder. An I-frame or intra frame, is a self-contained frame that can be independently decoded without any reference to other images. The first image in a video sequence is always an I-frame. I-frames are needed as starting points for resynchronization points if the transmitted bit stream is damaged. I-frames can be used to implement fast-forward, rewind and other random access functions. An encoder will automatically insert I-frames at regular intervals or on demand if new clients are expected to join in viewing a stream. The drawback of I-frames is that they consume much more bits, but on the other hand, they do not generate many artifacts. A P-frame, which stands for predictive inter frame, makes references to parts of earlier I and/or P frame(s) to code the frame. P-frames usually require fewer bits than I-frames, but a drawback is that they are very sensitive to transmission errors because of the complex dependency on earlier P and I reference frames. A B-frame, or bi-predictive inter frame, is a frame that makes references to both an earlier reference frame and a future frame Reference both preceding and succeeding I- or P-frames.

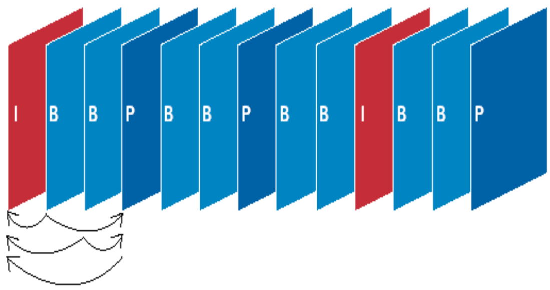

Fig 4. A typical sequence with I, B and P-frames

When a video decoder restores a video by decoding the bit stream frame by frame, decoding must always start with an I-frame. P-frames and B-frames, if used, must be decoded together with the reference frame(s). In the H.264/AVC baseline profile, only I- and P-frames are used. This profile is ideal for network cameras and video encoders since low latency is achieved because B-frames are not used.

D) Video Quality Measure

	HD CAMERA		
	PSNR	MSE	Size
MPEG-4/ H.264-AVC	32.4101	37.3311	
	32.9328	33.0976	1.04MB
	33.3337	30.1794	
MPEG-1	32.1232	39.8802	
	32.5517	36.1338	1.52MB
	32.7528	34.4987	
Microsoft Video1	31.7688	43.2709	
	32.501	36.5575	63.8MB
	32.6933	34.9741	
Uncompressed			225MB

In order to evaluate the performance of video compression coding, it is necessary to define a measure to compare the original video and the video after compressed.Most video compression systems are designed to minimize the Mean Square Error (MSE)between two video sequences *Ψ1* and *Ψ2*, which is defined as

$$MSE = (\sigma)^2 = \frac{1}{N}\sum_t \sum_{x,y}[\Psi1(x,y,t) - \Psi2(x,y,t)] \quad (1)$$

Where, N is the total number of frames in either video sequences.Instead of the MSE, the Peak-Signal-to-Noise Ratio (PSNR)in decibel (dB) ismore often used as a quality measure in video coding, which is defined as,

$$PSNR=10\log_{10}(peakval^2/MSE) \quad (2)$$

Where, MSE is the Mean Squared Error and Peakval is the Peak value of the signal [1].

IV. Result

In this section, the result obtained with the provided experimental setup is shown. To choose the best compression standard to implement in mobile robot, the video is recorded for 30s using different compression standards.

A) Experimental Setup

The mobile robotic platform available with the Mechatronics Laboratory of Mechanical Engineering department in Sinhgad College of Engineering is used to do the experiments. This platform runs on a 24V/7A battery, the power for the robot is managed using the power distribution board which regulates and distributes power to all electronic components of the robot. The robot is controlled through Atom PC runs on Microsoft Windows 7.

The robot can be fundamentally broken down into three blocks where each block is connected to the Atom-PC. The major blocks of the robot are namely

- Power management Unit
- Display Unit
- Motion Control Unit

These blocks further consist of the ARM cortex M3 based LPC1768 microcontroller base-boards, Ultrasonic sensors,

Sharp IR sensors and a webcam has been integrated with the robot, which can capture images and video. The webcam mounted on the robot is Logitech C920. The webcam support a high resolution image upto 15 MP.

B) Experimentation and Analysis

Calculate the Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) for a particular image in each video recorded with different standards for 30 seconds. To get an image, split the video into frames then take the individual image.

TABLE I

PSNR AND MSE COMPARISON-HD CAMERA

From the graph shown in figure 5, the PSNR value of H.264/AVC codac is better than any other standards. From table-I, the size of the video can reduce to a small value using this codac. So, the implementation of this codac for mobile robot data transmission algorithm will avoid the limited bandwidth problem

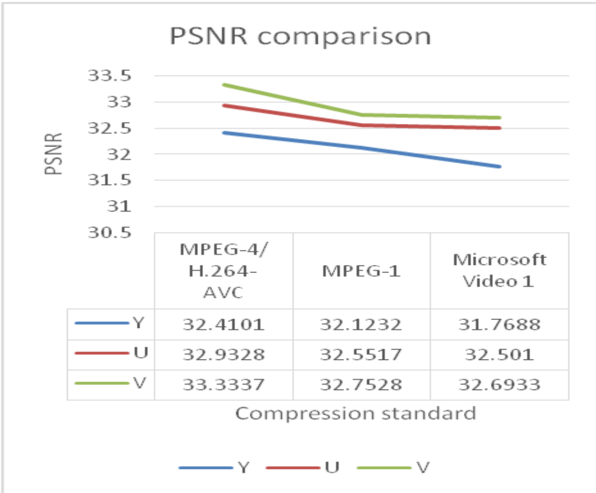

Fig 5 PSNR comparison

V. Conclusion

The new method to design data transmission and information extraction algorithm is proposed in this paper. Current method available needs more bandwidth channel to transmit the video. In this new algorithm proposed, the size of the video is reduced by applying H.264 codac.After compression, the video is transmitted to another system through Wi-Fi by using Dynamic Host Configuration Protocol (DHCP) server and the code written with the help of Python. It gives the higher peak signal to noise ratio, less mean square error and higher compression in size. The algorithm was implemented on the mobile robot platform available at the mechatronics laboratory consist of Atom Pc, Logitech C920 Pro. HD camera. The performance analysis shows the quality of the video is higher in H.264 implemented procedure compared to the other standards like inbuilt Microsoft video-1 and MPEG-1 standard. So the new design of data transmission algorithm is most suitable and easy to implement. This algorithm can be implemented in places such as hospitals for sequential monitoring of patient conditions in future to reduce the workload of nurses. Also the night vision cameras will give more efficiency to the system. This design can be utilized in any surveillance system to increase quality and easy analysis in the future by consuming less storage memory.

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