Rapid Prototyping of Wireless Image Transmission for Wildlife (Tiger) Monitoring System - A Preliminary Study

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***Abstract*—This paper proposes a rapid prototyping of wireless image transmission for wildlife monitoring system on Raspberry Pi. In this study, inputs based on the motion of surrounding activities were detected using a motion sensor and camera. The system is configured to capture frames in real-time of these activities and analysed using computer vision system toolbox available in MATLAB & Simulink. A Raspberry Pi that equipped with Broadcom BCM2836 system on chip (SoC) with processor performance of 900 MHz 32-bit quad-core ARM Cortex-A7 acts as a brain with a graphical user interface (GUI) that configures the systems and its peripheral. Images were transmitted to the host computer using Wi-Fi 802.11n (2.4GHz) transmission. Results obtained show that the proposed system capable of capturing and processing various size of images. Transmitted images have been through various processes, and finally, the decompressed images were obtained via the host computer.**

***Index Terms*—Image Transmission; Raspberry Pi; Wildlife Monitoring System; MATLAB.**

I. INTRODUCTION

We live in a world with an overburden of information strike us every minute. Everybody know the knowledge about the importance of wildlife for the earth, but the question is, how much far the awareness to take care about the wildlife that will bring a balanced ecosystem to the world that we live together.

Tiger is one of the wild animals threatened by extinction. According to the list by International Union for Conservation of Nature (IUCN), Panthera Tigris (tiger) is categorised as an animal with threatened categories, and it is critically endangered [1], [2]. Apparently, this animal will be extinct if there is no serious action taken. Its endangered status is an indicator of ecosystems in crisis, and since half of the last century, the numbers have been decreased from 3,000 to 500 individuals in 2003 [3]. The number continues to be decreased, and it is estimated to be only about 250 to 340 individuals in 2013 [4].

The cause that led to the extinction of the tiger includes the destruction of the habitat and poaching activities that uncontrolled. Hence, the National Tiger Action Plan has been formulated with a clear target for Malaysia to have an extra of 1,000 tigers in 2020, as an initiative to ensure that the number of this animal does not continue decrease [5].

To date, current equipment used to monitor wildlife as shown in Figure 1 is unfit for the purpose, since the camera units were unable to provide near-live reporting where the workers have to manually collect the image data which located inside the jungle with a dangerous situation and as they are unconcealable, they are often stolen. These factors combine to make the challenge of protecting tigers very difficult for those involved.

Figure 1: The current system uses a trap camera [6]

To portray the importance of this research, it is reported that the platforms have been evolved with the recent development and advancement of electronic consumers, including an embedded system, camera and advanced communication technology. To summarise a spectrum of related issues with the implementation of wildlife monitoring system is listed in Table 1.

Based on Table 1, the camera is the important hardware in wildlife monitoring that can provide clear information (image/video) that authority needed. However, most of the current system cannot provide near-live reporting because image/video are massive data. To overcome the weakness of the current system, wireless image transmission is a promising solution to be considered.

Table 1
Summary of Previous Research Related with the Wildlife Monitoring

Refs.	Hardware	Type of Data	Data Storage	Data Transmission Method	Application
[7]	Camera	Video	Tape	RCA Audio/Video Cable (18.3m)	To monitor avian (bird) nest activity
[8]	Remote-Trip Camera	Image & Sensor	Memory Card	Manually Collect (human-based)	Monitor mammals population
[9]	Cameras, 2.4GHz Opteron Processor	Video	230 GB Portable Hard Drives	Wireless 2.4 GHz Radio Signal (500m)	To monitor the behaviour of bears at the arctic circle
[10]	Camera, 400MHz Intel PXA255 XScale Microprocessor	Video & Sensor	4GB CF Card	802.11-based Wireless & Ethernet Cable	Monitor cross season behaviour of the animal
[11]	Camera, Digital Video Recorder	Video	100GB Hard Drives	6.4mm Multicore Coaxial Cable	Monitoring endemic bird species in tropical rainforest of New Caledonia
[12]	Camera, Processor XScale PXA2771, MSP430 Microcontroller	Video, Image & Sensor	Flash Memory	802.15.4 ZigBee network, IEEE 802.11b WLAN & 3G network	Wildlife monitoring
[13]	Camera Omni Vision OV7670, Atmel AT91SAM7X512	Image	Flash Memory	ZigBee transceiver & 3G network	Wildlife monitoring

This research aims at developing wireless image transmission for wildlife monitoring system on Raspberry Pi that equip with Broadcom BCM2836 SoC with processor 900 MHz 32-bit quad-core ARM Cortex-A7 [14]. In this proposed system, an image will be captured, processed and later being transmitted using wireless communication technology to the station of authority. With this system, immediate action can be taken compared to the current system that requires more people to be involved (human-based), less energy-efficient and consume more time.

The rest of the paper is organised as follows. The proposed system implementation is presented in section II. Details of the system implementation including input, process, output and data transmission are addressed in Section III. Results and analysis of this research are discussed in Section IV. Finally, conclusion and future works are given in Section V.

II. Proposed System

The system block diagram as shown in Figure 2 is designed to be in the standby mode to minimise the power consumption and increase the operational hour. Once the motion is detected, the system works to capture and store frames captured by the camera on the Raspberry Pi and store to the secure digital (SD) card. The system then transmits the image via Wi-Fi using samba method using file transfer protocol (FTP).

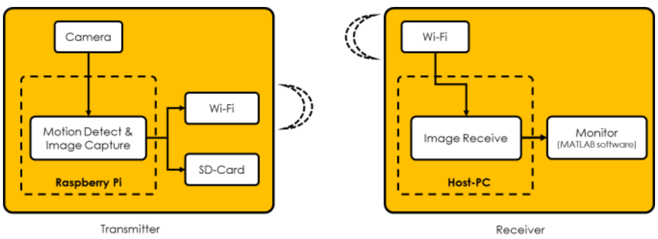


Figure 2: Proposed system block diagram

Each device that has the same Internet protocol (IP) address will have access to the image file. The image then being accessed using host-PC and display via the monitor.

III. System Implementation

To realise the whole implementation, all parts including camera, Wi-Fi dongle, motion sensor and Raspberry Pi board are assembled as shown in Figure 3. The proposed prototype is designed as compact as possible to make it easily concealed, to overcome one of the weaknesses with the conventional system.

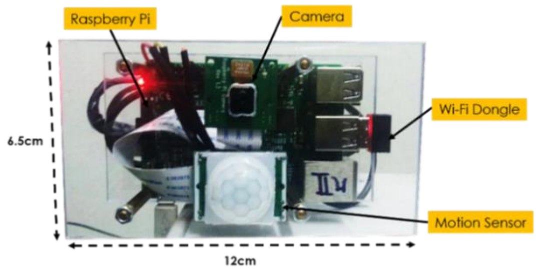


Figure 3: System implementation setup with Raspberry Pi

To execute this project, four (4) main parts have been identified, including an input, processing, output and data transmission

A. *Input*

This part consists of two (2) elements, which are motion sensor and camera unit. The function of the motion sensor is to sense the sign of activities as well as to configure the readiness of the system and the camera unit is an input device to capture images at the monitoring area. All captured image will be processed and analysed using computer vision Toolbox in MATLAB & Simulink [15].

B. *Process*

To extend the process, Raspberry Pi served as a brain with a Simulink graphical user interface (GUI) program that configures the peripheral. MATLAB software is used due to the availability of the computer vision system toolbox that can provide a comprehensive suite of algorithms and tools for object detection. An overview of a proposed system that has been designed using MATLAB Simulink is given in Figure 4. Generally, the system takes an image through Video for Linux Two API (V4L2) video capture block to provide an input to the Raspberry Pi hardware.

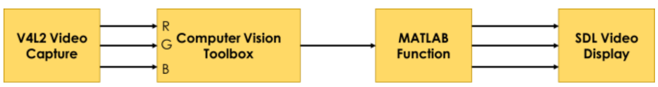


Figure 4: General structure for image or video processing based on V4L2

A general block diagram for computer vision system aims for moving object detection is given in Figure 5. The process is be divided into three (3) stages: pre, mid-level and post-processing. The pre-processing stage is designed as a colour space conversion (CSC) that converts colour information between colour spaces. It specifies the parameter of the colour spaces between red, green and blue (RGB) to intensity. The processing level consists of image analysis and enhancement techniques that allows the model designed to increase the signal-to-noise ratio (SNR) and accentuate features. The post-processing again performed the CSC to convert colour space to specify the parameter.

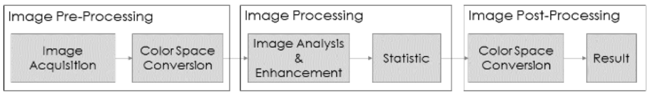


Figure 5: Pre-, processing and post- of moving object detection

Figure 6 shows the Simulink model-based design of the moving object detection using MATLAB & Simulink software. A system is developed to get input from the stationary camera for detecting moving objects. The internal of the subsystem model based-design consist of adding Simulink block function such as enable subsystem, the development of moving object detection using optical flow technique system design and trigger subsystem.

For the enable subsystem, once it received the signal from the sensor, the camera will be activated. Then, the acquired image from the camera will be processed through the development of moving object detection using optical flow technique system design before it brings out the trigger subsystem. The moving object detection system design detects the existence of the motion in camera field, and this subsystem will save a snapshot to a file in the Raspberry Pi build directory. Simulink model-based design of the developed system that is deployed in the targeted hardware Raspberry Pi board model B+ is given in Figure 7.

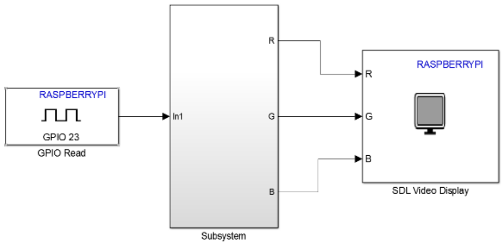


Figure 7: Simulink model-based design in the targeted hardware Raspberry Pi board model B+

C. Output

For the finishing part, any images that are saved in Raspberry Pi file will be shared with the host computer via a wireless router. It can be accessed by the user using GUI that has been developed as shown in Figure 8.

Figure 8: GUI for wildlife surveillance system

D. Transmission Method

Samba [16] server is an application that enables the file sharing between Linux and Windows operating systems. This application will enable the file in the Raspberry Pi to share their contents with the host computer through file transfer protocol (FTP). Each device that has the same Internet protocol (IP) address will have access to the file, and the implementation concept is depicted in Figure 9.

Figure 9: A Samba server configuration

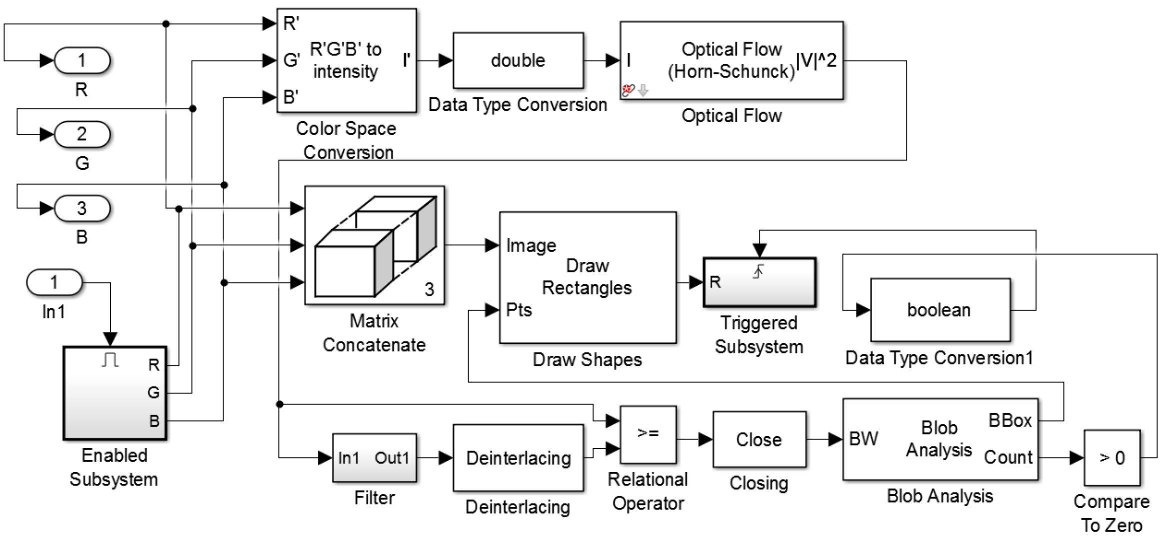


Figure 6: The subsystem develop model design

IV. Experimental Results and Analysis

This section elaborates the results obtained and discussions on image processing and camera sensitivity.

A. Image Processing

Figure 10 explains the different stages of computer vision block function and results of moving object detection from the Simulink model.

Figure 10(a) shows the original image that is obtained from the image acquisition toolbox; then the image obtained converted from the RGB form into intensity colour form which is white and black through the CSC block as shown in Figure 10(b).

Figure 10(c) and (d) show the image before and after the filtering process with a median filter that has been applied to remove motion artefacts from images composed of knit top and bottom fields of an interlaced signal. Deinterlacing block has been used, and the results are shown in Figure 10(e), while Figure 10(f) displays the morphological closing on intensity or binary image.

Figure 10(g) shows the detected moving object that is exist in camera as shown by the rectangular white shape. Example of the final result 120×160 frame image after the decompression image technique are as shown in Figure 10(h). It is clearly shown that the proposed solution successfully captures, process and finally generate the output images as expected.

Pre-Processing:

- Image Acquisition
- Color Space Conversion

(a) Original image

(b) Intensity image

Mid Level-Processing:

- Image Analysis & Enhancement
- Image Restriction

(c) Unfilter image

(d) Filter image

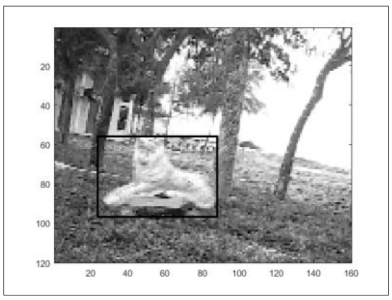
(e) Deinterlacing image

(f) Closing image

Post-Processing:

- Color Space Conversion
- Image Detected

(g) Detect image



(h) Save image in Pi

Figure 10: Different stages of computer vision block function and results of moving object detection

B. Camera Sensitivity

The sensitivity of the camera is tested with the different size of images frame as tabulated in Table 2. In case of 160×120 frame size, the camera unit able to sense, capture and save the motion in Raspberry Pi within the distance of three (3) meters without any delay. However, the distance can be extended to six (6) meter with using of 340×240 image frame size with five (5) seconds delay. By using 640×480 image frame size, the distance can be maximised to eight (8) meters with 39 seconds of delay.

Table 2
An Evaluation of the Camera Unit Sensitivity

Image Size	Distance (m)	Delay (s)
160 × 120	3	0
340 × 240	6	5
640 × 480	8	39

The cause that leads to the delay in detecting the image is because the small of sample time used, which the processor needs to finalise the same amount of instructions in short of time. This problem can be solved by changing the sample time using with several modifications in Simulink model-based design or replacing with a better resolution of the camera.

V. Conclusion

Wireless image transmission for wildlife monitoring system on Raspberry Pi has been presented in this paper. The proposed system capable of capturing and processing various size of images and the images have been through various processes, and finally, the decompressed images were obtained via the host computer.

For future works, the system designed is expected to help the agencies involved with protecting wildlife to prevent the number of extinction. The combination of communication and visual monitoring can be highly potential to be used in future. A lot of study and research should be intensively carried out to make a better system especially in terms of data precision and live data reporting.

Acknowledgement

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