Comparison of the LoRa Image Transmission Efficiency Based on Different Encoding Methods

Ching-Chuan Wei, Pei-Yi Su, and Shu-Ting Chen

Abstract—**The booming Internet of Things (IoT) can be seen in all areas of daily life. In the traditional wireless sensing network technology, there are difficult factors such as insufficient transmission distance or high power consumption. The emergence of LoRa (Long Range) technology has broken the difficult factors of traditional wireless sensing network technology. Due to the demand for image in IoT applications, the LoRa technology of low data rate will be designed to transmit the image of high data quantity in this paper. Different encoding methods will influence the transmitted file size and the transmission efficiency. Two major encoding methods are presented to conduct the comparison experiment of image transmission efficiency. PSNR (Peak Signal-to-Noise Ratio), SSIM index (Structural Similarity Index) and transmission time are used to evaluate the image transmission efficiency under different encoding method.**

Index Terms—**Internet of Things (IoT), LoRa, PSNR (Peak Signal-to-Noise Ratio), SSIM index (Structural Similarity Index), transmission time, JPEG, Webp, Base64.**

I. INTRODUCTION

In recent years, the booming of the Internet of Things has been seen in various fields of daily life, such as military, commerce and medicine [1]-[3]. In the traditional wireless sensing network technology such as Zigbee, Bluetooth, 3G/4G and other wireless transmission technologies, there are difficult factors such as insufficient transmission distance or high power consumption [4]-[6]. The emergence of LoRa broke the difficult factors of traditional wireless sensing network technology.

Firstly, regarding ZigBee, it is an 802.15.4 IEEE technology of short distance and low data rate, and supports multiple network topologies. The free frequency bands such as 2.4GHz, 915MHz and 868MHz are used, and the transmission distance is below hundred meters [4]. For long distance application, mesh topology and multi-hopping are inevitable. That makes the wireless sensor network based on ZigBee more complicated and unstable in practical application. Secondly, Bluetooth is a technology of low-power, short distance and frequency hopping. It is an IEEE technology of 802.15.1. The free frequency band used is 2.4 GHz and the transmission distance is below hundred meters [5]. The similar problems for long distance transmission arise in Bluetooth technology. Thirdly, LoRa is a newly developed wireless technology which can overcome the above problems. Thus, LoRa attracts more

and more attraction recently.

LoRa's advantages include low power consumption, long-distance transmission and low cost [7]. This technology is a low-power wide area network (LPWAN) from Semtech. It uses Chirp Spread Spectrum (CSS) and spread-spectrum technology to achieve the low-power and long-distance transmission. Due to the long-distance transmission characteristics, the network topology can be a star topology. Thus, it saves the cost of the repeater and reduces the complexity of the network deployment. The transmitting current consumption in LoRa is about dozens of milliamperes, and the sleep current consumption is about several microamperes [8].

At this stage, the way to use LoRa technology for image transmission is not common, because the program to transfer pictures consumes a lot of time compared with WiFi. In this paper, we use different encoding methods to compare the transmitted image quality and the time they take for LoRa to transfer images. This paper is organized as follows. The second section mainly describes LoRa transmission parameters, JPEG Image Formats, Webp Image Formats, Base64 coding and System Architecture. The experimental results are discussed in the third section. Finally, we draw a conclusion in the fourth section.

II. SYSTEM

A. LoRa Transimission Parameters

Adjusting the different parameters of LoRa will affect the packet transmission rate, sensitivity and transmission distance [9]. The main parameters include: TP (Transmission Power), BW (Bandwidth), SF (Spreading Factor) and CR (Coding Rate). described as follows:

- **TP (Transmission Power)**: The switchable transmission power is adjustable from −4 dBm to 20 dBm. When the TP is adjusted to be higher, the power consumption will be higher and the signal-to-noise ratio will be higher.
- **BW (Bandwidth)**: It will affect the packet transmission rate, sensitivity and transmission distance. The adjustable range is from 125 to 500 KHz. When the BW is adjusted to the higher value, the transmission rate will increase, but the sensitivity and transmission distance will decrease.
- **SF (Spreading Factor)**: It will affect the packet transmission rate, receiving sensitivity and transmission distance. The range is from 7 to 12. When the SF is adjusted to a larger value, the transmission rate will decrease, but the receiving sensitivity and the transmission distance will increase.

- **CR (Coding Rate)**: It will affect the anti-interference ability and transmission rate of the packet. The adjustable values are 4/5, 4/6, 4/7 or 4/8. When the CR is adjusted to the larger value, the transmission rate will decrease, but the anti-interference ability will increase.

B. JPEG Image Formats

JPEG compression is the most commonly seen technology and the most famous distortion compression technology [10]. It can compress the image file to the appropriate size according to the image quality required by itself. The steps of JPEG compression technology are in the following: (1) Convert the color space of the image from RGB to the color space of YUV, (2) Cut the individual color space of YUV by 8*8 matrix, (3) by using DCT (Discrete Cosine Transform), the image value are transformed and then divided into the DC part (DC coefficient) and the AC part (AC coefficient) (4) Quantize the image matrix value, and that constitutes the major distortion in JPEG compression, (5) Entropy Coding: Differential Pulse Coding for DC, Zig-Zag Running Length Coding for AC, and Huffman coding.

C. Webp Image Formats

The Webp format, including lossless and lossy compression techniques, was developed by Google. Using webp lossy compression techniques will make the image file size much smaller than that by JPEG compression. The Webp lossy compression process is similar to the jpeg compression process [11]. There are two major differences between them. Firstly, Webp uses predictive coding. Secondly, Webp compression uses Boolean arithmetic coding, but the JPEG compression uses Huffman coding. It thus improves the compression effect.

D. Base64 Coding

Base64 is a common code used to transmit data on the Internet [12]. It mainly converts the binary value of the data into 64 ASCII (American Standard Code for Information Interchange) symbols, where its ASCII symbols includes 10 numbers, 26 uppercase and lowercase Latin letters, plus signs, slashes, etc. The Base64 conversion process is as follows: First convert the data into binary and sort it by 3 bytes. If the sorted value is less than 3 bytes, it will be filled with 0. Then each group goes to the corresponding symbol according to the Base64 corresponding to ASCII table. The Base64 encoding image file needs to save as other encoding file for saving or transmission. Although Base64 encoding will increase the character length by 1/3, we choose it as the transmission file format because it is compatible with the packet format of LoRa transmission [13].

E. System Architecture

The main flow chart of the transmission and reception of LoRa is shown in Fig. 1 and Fig. 2. First, the transmitter system will be initialized. Then read the JPEG file and convert the JPEG file into the Webp file format. Next, LoRa starts transmitting the packets. After transmitting all the packets, the LoRa is converted into the receiving mode. After receiving the transmitted packets, the receiving end determines whether it completely receives all the packets. If all the packets have been completely received, the transmitter will end the thread. Conversely, LoRa will continue to transmit the lost packets until the received packets are not lost. As shown in Fig. 2, first the system will initialize and set the LoRa status to receiving mode. After receiving, the system will judge the integrity of the packets. If some packets were lost, the receiving end will convert to the transmission mode to transmit the number of the lost packets. Otherwise, the receiving end will send a message that all packets have been received, and then the thread will be closed.
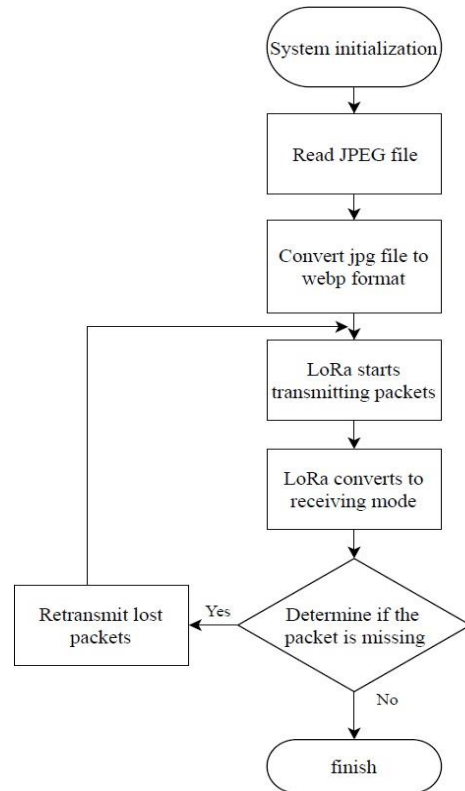
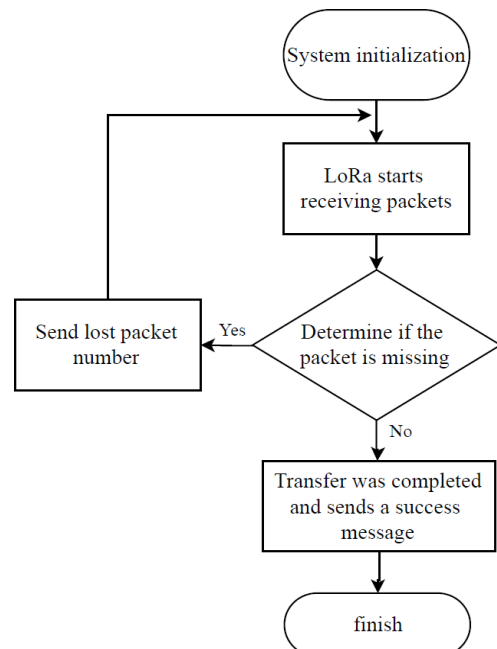Fig. 1. The flow chart of LoRa transmitter.

Fig. 2. The flow chart of LoRa receiver.

III. EXPERIMENTAL RESULT

The transmitter and receiver devices consist of Raspberry pi 3 B + and Semtech sx1276 LoRa chips. The experimental site of transmitter are located on the 9th floor of the building of Chaoyang University of Science and Technology, and the other receiving end is placed near Meiqun Bridge and Tucheng Road in Dali District, Taichung City, Taiwan. According to Google Maps, the communication distance between the transmitting end and the receiving end is about 1.5 kilometers, as shown in Fig. 3.
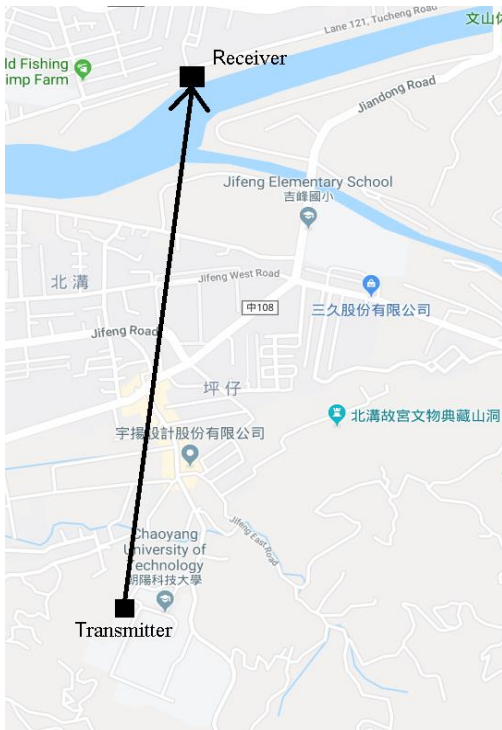

Fig. 3. Map of the experiment location.

In the experiment, the parameters fixed by LoRa are the frequency band 868 MHz, TP=17dBm, BW=500 kHz, SF=7, CR=4/5. We use different image formats for LoRa transmission and evaluate the transmission effect. The evaluation parameters of transmission effect includes RSSI (Received Signal Strength Indicator), PSNR (Peak Signal-to-Noise Ratio), SSIM (Structural Similarity index), and transmission time. The original picture with 200×150 pixels is shown in Fig. 4. The actual placement of the transmitting node and the receiving node are shown in Fig. 5. Fig. 6(a) shows the result after transmission using the jpg format. Fig. 6(b) shows the result of the transmission using Webp and then Base64 encoding.

Fig. 4. Experimental original image.

Fig. 5. The actual position of the transmitting node and the receiving node.

Fig. 6. The transmitted images using: (a) JPEG (b) Webp and Base64.

PSNR is used to evaluate image quality. The larger the PSNR, the smaller the image distortion. However, it is pointed out in the research report that PSNR is different from human perception [14]. SSIM is used for measuring the similarity between two images and thus is designed to improve the traditional methods such as PSNR. Therefore, we add the SSIM evaluation parameter to determine the similarity and quality between the transmitted and the original pictures. The SSIM range is 0~1. When it is closer to 1, the transmitted image is closer to the original image [15].

The transmission experiments for JPEG encoding and Webp + Base64 encoding were individually conducted for three times. The result data were averaged and shown in Table I. The original image size compressed by JPEG is 20.03 KB. The data obtained by transmission test are Total packet number=81, RSSI ((Received Signal Strength Indication) = -97.0 dBm, Packet number of success =28.7, PSR (Packet Success Rate) = 95.7%, PSNR = 33.84 dB, SSIM=0.904 and transmission time = 47.7 s. The other method (Webp + Base64) compressed the file size to 5.51 KB. The result data obtained by the transmission test are Total packet number=23, RSSI=-88.7 dBm, Packet number of success=21.7, PSR=94.0%, PSNR=33.84dB, SSIM=0.904, and transmission time =25.7 s. It can be seen that PSNR and SSIM of the two method are the same. The viewing image is acceptable to the human eye However, the transmission time for Webp + Base64 encoding method is

much smaller than that for JPEG. The difference of transmission time between the two methods mainly arise from the file size after compression coding. The smaller transmitted file size require the smaller transmission time.

TABLE I: EXPERIMENT RESULTS

Transmission format	JPG	Webp + Base64
Coding size(KB)	20.03	5.51
Total packet number	81	23
RSSI (dBm)	-97.0	-88.7
Packet number of success	28.7	21.7
PSR(%)	95.7	94.0
PSNR (dB)	33.84	33.84
SSIM	0.904	0.904
Transmission time	47.7 s	25.7 s

IV. CONCLUSION

Because of the large data amount of image, it is critical to transmit the picture. The LoRa technology is primarily designed for low data rate transmission. However, in practical application it is essential to integrate the data transmission and image transmission to enhance the IoT value.

The encoding method severely influences the transmission file size of image, and thus the transmission time. Although the method of Webp plus Base64 encoding has less PSR, its compression file size is almost one half of that of JPEG. Therefore, the transmission time is also almost one half of that of JPEG. From our experimental results, we found that the LoRa image transmission with Webp plus Base64 encoding requires the time of 25.7 s, which is acceptable for practical application. This method apparently improves the transmission time. Therefore, it is feasible to develop a picture transfer using LoRa technology.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Ching-Chuan Wei makes contributions to the experiment design, explanation and article reviewing. Pei-Yi Su and Shu-Ting Chen carried out the experiment, analysis and writing the paper. All authors read and approved the final manuscript.

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