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Research on the Joint Source Channel Coding of Wireless Sensor Network

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Abstract: With the development and wide application of multimedia technology it has increased image, sound and the transmission of other signal to a great extent which is a great challenge for the wireless communication, especially for wireless sensor networks. Wireless sensor network has the flexibility, adaptability, easy construction and other characteristics, in order to guarantee the transmission quality of the image in the channel, at the same time it needs to optimal encoding for the source and channel. Based on a wireless sensor network, this paper proposes a joint source and channel coding algorithm and the use of FPGA technology builds the source channel coding system, the experiments prove that the proposed new algorithm can improve the source and channel coding efficiency and it has anti-interference ability and good robustness.

Keywords: Wireless sensor network, adaptive coding algorithm, FPGA, robustness

INTRODUCTION

Wireless sensor network is a novel network based on the data which can be real-time monitoring coverage area through the stationary nodes or active node (Akyildiz *et al*., 2007). When the user needs to relevant data it only need to pay attention to the event notification to the wireless network and not according to the network address to send a command to the specified node, that is to say the address coding of wireless node is constantly changing in the whole network, so the significant characteristics of the wireless sensor network is dynamic and self-organization its characteristics are help for the transmission of image and sound.

Wireless sensor network is widely used in environmental monitoring, community security, national defense etc., so network needs to have transmission image, sound and other multimedia information, so as to adapt to the demand of diversity, the wireless sensor network source and channel coding are provided new challenges (Sun *et al*., 2011; Duan *et al*., 2013; Tan *et al*., 2011). Communication system code consists of source coding, channel coding and modulation, the most commonly used source code technique includes Hoffman coding, arithmetic coding, predictive coding and wavelet transform coding, in which channel coding technology included RS coding, convolutional coding, Turbo coding and low density parity check code its communication system coding technology is schematically shown in Fig. 1.

Because the channel bandwidth of wireless sensor networks is less, in order to more effective use channel it need to compression coding for the source signal (Arjmandi *et al*., 2011); compared with the wired network, the wireless network has higher open, relatively small security, there are many interferences in the channel, even threatening, so it need to encode for the channel, to enhance the robustness of the channel, reducing the error rate of signal (Qiu *et al*., 2011). However, after the degree of source coding compression is increased, the signal is transferred in channel and its error rate will be increased with the channel; enhancing the anti-jamming ability is to reduce the source compression rate as the price, so we can say that the source coding and channel coding is a pair of contradiction. In order to reconcile these two encoding characteristics, source coding and channel coding need to be considered at the same time, a joint source channel coding is proposed, that is to say, according to the different signals and channel bandwidths, source compression parameters are set, or according to the source, selecting the appropriate channel, so as to achieve the effective and safe transmission of multimedia signals.

Wireless sensor networks overview: Wireless sensor network consists of large number of nodes in the network dynamic composition of organization form, the communication channel between nodes is changing according to the actual situation, such as when a node's energy can not be normal supply channels, other nodes will automatically disconnect and communication and dynamic connected to its nearest the node, so as to ensure the whole network channel. The original data sent by the node to compression by the source encoder and efficient use of the bandwidth of the channel, but also the need for the channel coding, improve the disturbance tolerance ability, reduce the bit error rate signal, when the data through the channel to reach the receiving end, need

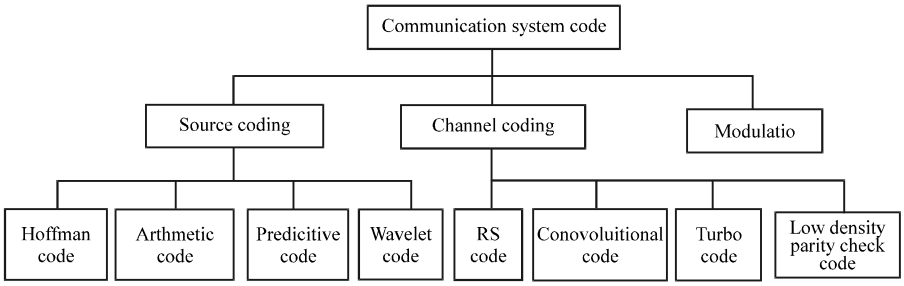

Fig. 1: Communication system coding

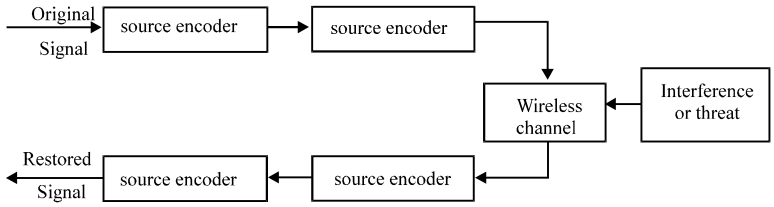

Fig. 2: Schematic diagram of the wireless sensor network communication system

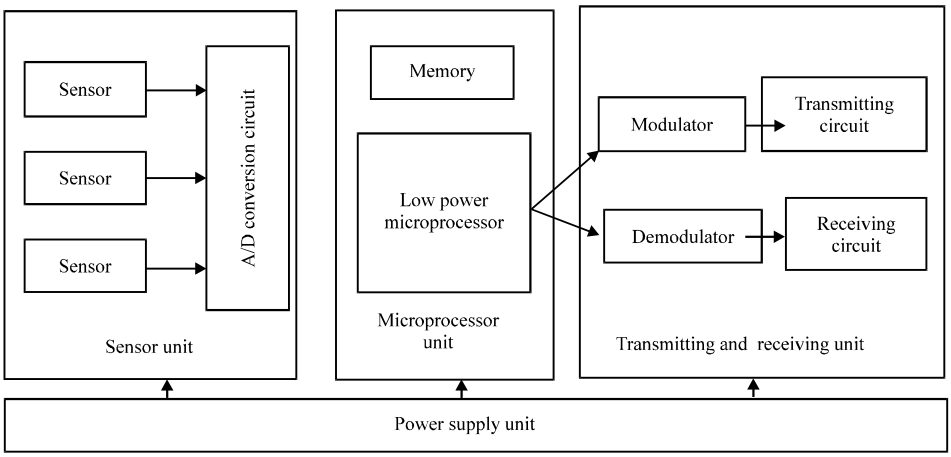

Fig. 3: Wireless sensor network node typical structure

to loop through the channel decoder and source decoder data reduction (Yang *et al*., 2013; Incel, 2011). The communication system of wireless sensor network diagram.is shown in Fig. 2.

The nodes of wireless sensor network plays the functions of data collection, data collection and data transmission and reception, the node is composed of sensor unit, microprocessor unit, data sending or receiving unit and power supply unit. According to the measured data's different it needs to select the appropriate sensors, such as temperature sensor, pressure sensor and so on; microprocessor is as far as possible to choose the low power type which is conducive to prolong the node life; the power supply unit can choose active power supply or passive power, in which the active power includes batteries, lithium batteries and so on and passive power supply includes solar power, wind power generation etc..Wireless sensor network node structure is shown in Fig. 3.

The communication protocol of wireless sensor network adopts five layer structure' WSN protocol stack which often uses IEEE802.15.4 standards, Zigbee standards, etc., when it carried out the source code it needs to consider the MAC layer's data frame transmission rate that should be synchronous with the modulator which requires the task management system to

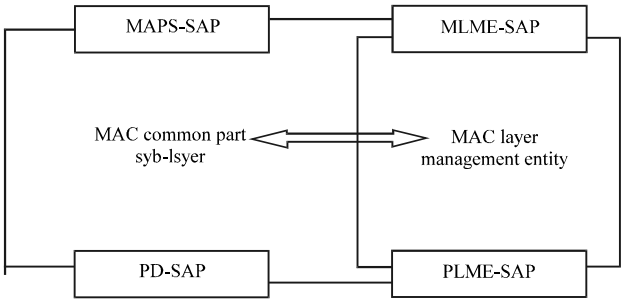

Fig. 4: MAC layer data transmission model

coordinate and solve; In the channel coding it is the need of network layer structure docking with MAC model, this MAC common part sublayer can be better resistance interference of external signals, to achieve efficient use of MAC layer management entity. Data transmission model of MAC layer is shown in Fig. 4.

WIRELESS SENSOR NETWORKS ADAPTIVE CODING ALGORITHM

Wireless sensor network is composed of nodes connected by the adaptive network, the number of wireless nodes will be increased and changed with the use of time, the wireless channel will also change dynamically, the channel bandwidth is limited which requires the network with the ability of source and channel coding efficiency, to adapt the external environment and internal communication environment's constantly changing, adaptive coding algorithm is put forward in this paper it can be link source coding and channel coding, considering the influence of both on data transmission quality it can achieve optimal coding.

The source code is the description of the original data, the data contains compressed information. When the data is described, the more detailed is not the better, otherwise it will cause too large data flow, the speed of data transmission in the channel is greatly reduced. However the data description can not be too simple, the minimum is to express the main features of the data, so according to the period of time's specific communication needs it needs to adjust the dynamic data compression ratio. Wireless sensor network adaptive coding is schematically shown in Fig. 5.

The design idea of joint source and channel adaptive coding algorithm carries out the bit stream encoding for the original signal, each bit stream contains information source. Through the control of source coding and channel coding parameters it can set the bit stream generated by the number and quantity, when the channel bandwidth is smaller it can reduce the number of bit stream, however the receiver can also correct decoding for the bit stream, to construct the correct information, if through the bit stream number is larger, the reconstructed signal is better quality. Set that the source is $S = (s_1, s_2,...s_k)$, the LDPC code conversion can be seen:

$$R = S'H_{LDPC} \quad (1)$$

In which, H_{LDPC} is LDPC code coefficient matrix. After the wireless sensor network node acquaints the data information, the original information source can carry out source coding by LDPC code conversion, so that the original information will be changed into n bit stream, at the same time the channel carries out LDGM code conversion and the relay channel pluses data parity bit its channel has coding error correction function, channel coding can be expressed as:

$$Ru = H^{T}_{LDGM} \quad (2)$$

Among them, H_{LDGM} is used as the coefficient matrix of LDGM codes as, so the relay channel data check matrix can be expressed as:

$$Tu = H^{T}_{LDGM}P \quad (3)$$

where, P is the check base matrix. Through the above transformation, the source bit stream can be expressed as:

$$\sum_{i,j}\alpha_{i,j} = 1 \quad (4)$$

$$\sum_{i}\beta_{i} = 1 \quad (5)$$

$$\sum_{j}\eta_{j} = 1 \quad (6)$$

Set that the number of bit stream is λ, then:

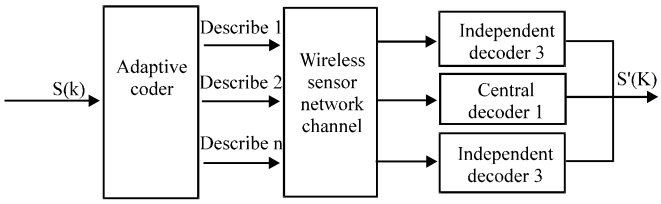

Fig. 5: Wireless sensor network adaptive coding schematic diagram

$$\lambda = \sum_{i,j} \frac{j}{i+j} \alpha_{i,j} \tag{7}$$

Therefore, the total rate of joint source channel coding is:

$$\sigma = 1 - \frac{\lambda \sum_{j} \eta_j + (1-\lambda) \sum_{i} \beta_i}{\sum_{i,j} \alpha_{i,j} - (1-\lambda) \sum_{i,j} \frac{\alpha_{i,j}}{i+j}} \tag{8}$$

THE JOINT SOURCE CHANNEL CODING SYSTEM

According to the design idea of joint source channel coding algorithm, this paper constructs a joint source-channel coding system based on FPGA, the system is the use of 12 wireless nodes that has built the simple wireless sensor network, the wireless nodes will collect information through the radio frequency circuit to transmit out, FPGA is the realization of baseband transmission function and finally it is showed the relevant information in the PC user interface. The joint source-channel coding system structure diagram is shown in Fig. 6.

In the design of baseband part it is the need for logic circuit design and input through the Verilog HDL language, in which the logic circuit uses a joint source channel adaptive coding algorithm, to carry on the circuit function simulation, if the simulation has problems, the system needs to modify the circuit structure, until the simulation is correct and then to carry on the logic comprehensive optimization, finally the BIT file, simulation net table and the implementation report can be get, so as to download the configuration is used for the system parameter setting.

In order to improve the speed of data transmission source in the channel, the received data can be stored in dual-port RAM, because the microprocessor has very quickly for the access speed of RAM. In the data storage it is the need for address assignment, where the use of sequential allocation mode, when read data it also uses sequential address read mode, this method has the advantages of the use of simple, fast reading speed etc.. Dual port RAM data encoding is schematically shown in Fig. 7.

The experimental results and conclusions

The joint source channel coding system is established in this paper, to verify the performance of adaptive coding algorithm. In the construction of the wireless sensor networks, wireless nodes are in turn it can test node number on the bandwidth of wireless sensor network, so as to study relationship between node number and bit error rate. In the setting of the coding system it needs to keep synchronous input clock of dual port RAM with output clock, making the write address and read address can order, so as to achieve the correct and fast data access.

When the source of information is carried out encode it can be set a different compression ratio and carry out LDPC code conversion for the tested images. Transform layers can be set to 6 and 10 and then to observe and study the peak signal noise ratio and the maximum error, according to the experiment results, the best compression ratio can be get, to carry on system optimization, to full use of the channel bandwidth according to the dynamic application environment, source coding experimental results are shown in Table 1.

The use of LDGM code conversion carries out the channel encode, at the same time the channel is applied the source of interference, then change the number of nodes in wireless sensor networks, the occupancy rate of wireless channel is the change of dynamic state, finally statistical signal bit error rate under different nodes, the results is shown in Fig. 8.

Through the experimental results it can be drawn that with the source compression ratio increases, the peak signal noise ratio decreases, however the maximum error increases, the optimal source compression ratio is 8 to 16. Through the contrast channel error rate before and after using the algorithm, the joint source-channel coding algorithm is proposed in this paper it can improve the source and channel coding efficiency and it is the advantages of simple, low bit error rate and anti-interference ability, at the same time it can enhance the robustness of wireless sensor network.

We consider a network sensor node is randomly distributed in a 50×50 m size area. The number of sensors

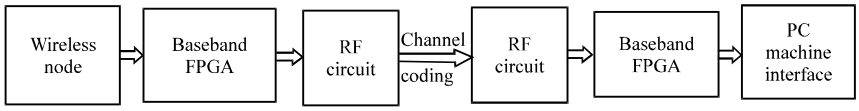

Fig. 6: Structure diagram of joint source channel coding system

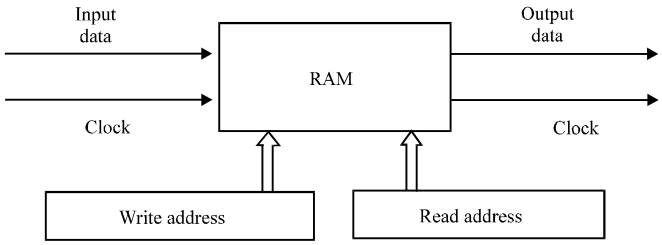

Fig. 7: Dual port RAM data encoding schematic diagram

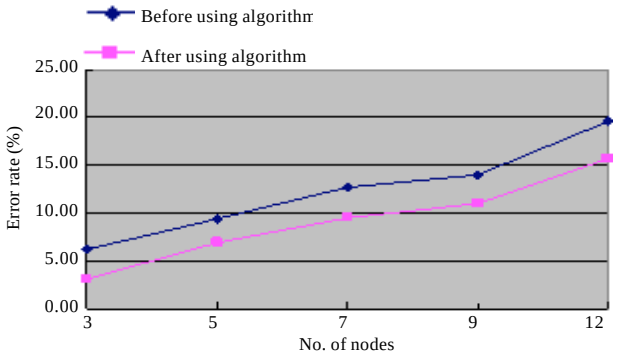

Fig. 8: Channel coding experimental results

Table 1: Source coding experimental results

	LDPC code conversion layers =10		LDPC code conversion layers =6	
Compression ratio	Peak signal noise ratio	Maximum error	Peak signal noise ratio	Maximum error
2	55.6	05.2	45.2	10.6
4	42.7	09.8	31.5	19.1
8	33.2	14.2	27.8	25.7
16	29.5	27.9	25.3	39.0
32	24.1	35.6	21.7	49.2
64	11.6	40.1	09.5	54.8

is in the network, the network scales n is from 10, 20 to 60 and so on. Each sensor has an initial energy of 1j, base station is located in (25,150). Each sensor generates a data packet size is 1000 bits. We compared this paper in section fourth presents the data stream protocol design, has provided for comparison and verification of conditions[10,11]: (a) sensor allows the implementation of the polymer network packets, (b) no sensors were allowed to polymerize the packet. The experimental results are shown in Fig. 9.

The horizontal axis in the graph is network scale, the longitudinal axis is life cycle, OPT1 and MLDR1 is an aggregation algorithm life cycle, OPT2 and MLDR2 is life cycle of aggregation algorithm it can be seen from the graph, difference between MLDR and integer operation algorithm OPT is not apparent and difference is very apparent whether it uses the data aggregation algorithm, there are about 20 times the gap. In conclusion, the data stream protocol control algorithm MLDR is close to the optimal state and it can achieve data acquisition life cycle maximum.

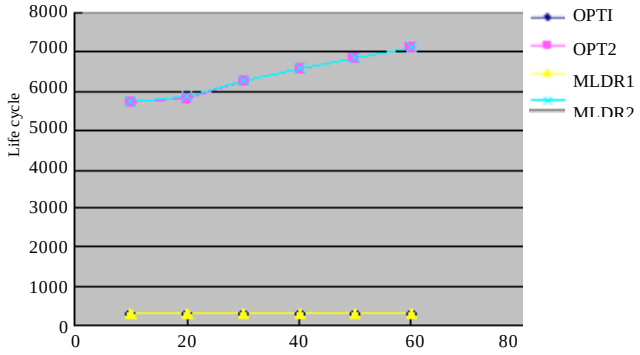

Fig. 9: Experimental results

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