Medical Image Transmission Strategy Based on Bandwidth Sensitivity and Multi-resolution

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***Abstract*—On the basis of traditional image transmission technology, the medical image transmission strategy based on bandwidth sensitivity and multi-resolution is proposed in mobile transmission environment. According to current network bandwidth, remaining battery power of mobile terminal equipment, screen resolution of mobile device supporting and real-time transmission requirements, the strategy selects the image replica with the optimal transmission resolution as the transfer object. Experiments show that the strategy is effective.**

Keywords-medical image; transmission strategy; bandwidth sensitivity; multi-resolution

I. INTRODUCTION

With the rapid development of information technology, more and more applications involve image transmission. Generally speaking, image data especially medical image data present many characteristics such as the complex data structure and large amounts of data, etc. So the transmission cost of medical image data is higher than that of text data. At present, many researchers at home and abroad are keen commitment to research image data transmission. The research mainly concentrates on the aspects of image compression[1,2], communication control[3,4] and transmission strategy[5,6]. The development of mobile Internet realizes the transformation of image transmission from traditional communication network to mobile communication network. So that the users can get rid of the restriction of time and space, can achieve the required information at all times and places. In the medical field, health care professionals can also use mobile devices to review patient information through mobile communication network whenever and wherever possible, which greatly improves work efficiency of health care professionals. However, new opportunities also have brought more great challenges. The transmission of medical image data faces two problems in mobile environment: 1) Because of the particularity of the application scenario, image data present three characteristics of high dimensionality, high resolution and massive amount of data. 2) Mobile network environment generally has the characteristics of complex network structure, poor network stability and narrow bandwidth. Therefore, it is not feasible to adopt the traditional image transmission strategy in the mobile communication network.

The paper proposes a medical image transmission strategy based on bandwidth sensitivity and multi-resolution. According to current network bandwidth, battery power of mobile terminal equipment, screen resolution of mobile device supporting and real-time transmission requirements, the strategy selects image replica with optimal transmission resolution as transfer object. The strategy can reduce transmission data and time, and save transmission bandwidth.

II. MEDICAL IMAGE TRANSMISSION STRATEGY

Through the research of medical image transmission in a mobile environment, select three factors, image content, network bandwidth and image resolution to establish replica selection model. For the same piece of medical image, select image with appropriate transmission resolution as the transfer object according to the current network bandwidth. For example, when network bandwidth is relatively larger, the strategy chooses a higher resolution image replica as the transfer object. In this way, network bandwidth can be made full use of to get the optimal medical image. However, when network bandwidth is relatively lower, in order to reduce the waiting time, the strategy selects a lower resolution image replica as the transfer object.

In the pretreatment process, medical images are divided into multiple blocks. The blocks corresponding to the location of the diagnosis and treatment will be marked with MUA (Medical Useful Area). Then, image blocks are processed by a variety of resolutions, and the corresponding replicas of image blocks are stored. Finally, each image block is processed into multi-resolution replicas, which are stored in the medical image database. Therefore, each image block is stored in the form of replicas with a variety of resolutions. Next, the strategy focuses on how to balance transmission time and image quality according to current network bandwidth, and select the appropriate image replica as the transfer object.

In order to establish the relationship between network bandwidth and transmission resolution, the resolution of the block is defined as R_i, the interval of R_i is defined as $[r_l, r_u]$, where r_l represents the lowest resolution, r_u represents the highest resolution. Similarly, the interval of wireless network bandwidth B_j is defined as $[b_l, b_u]$, b_l is minimum value, and b_u is maximum value.

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The resolution interval [r_l, r_u] is divided into n sections, then R_i can be expressed as Formula 1.

Formula 1: $R_i = r_l + \frac{i \times (r_u - r_l)}{n}$, $i \in [1, n]$, where n is the number of sections.

Similarly, network bandwidth B_j can be expressed as Formula 2.

Formula 2: $B_j \in [b_l + \frac{(i-1) \times (b_u - b_l)}{n}, b_l + \frac{i \times (b_u - b_l)}{n}]$

Because the parameter i is an integer value, Formula 3 is obtained.

Formula 3: $i = \left\lfloor \frac{(B_j - b_l) \times n}{b_u - b_l} + 1 \right\rfloor$

Based on above assumptions, the relationship between R_i and B_j is derived, as shown in Formula 4.

Formula 4: $R_i = r_l + \left\lfloor \frac{(B_j - b_l) \times n}{b_u - b_l} + 1 \right\rfloor \times \frac{r_u - r_l}{n}$

According to Formula 4, determine the optimal resolution according to current network bandwidth, and select the block with the optimal resolution as the transfer object.

The resolution obtained by Formula 4 is the average resolution of the entire image. In order to preserve the integrity of medical information, image blocks that contain MUA regions require higher resolution. Otherwise the loss of image information will cause serious consequences. The resolution of MUA region remains unchanged. However the average resolution of the entire image is obtained by Formula 4.

Suppose image area is S. The area of MUA is S1, and its resolution is R1. The rest area is S2, and its resolution is R2.

Then the average resolution of the image is obtained by Formula 5.

Formula 5: $R_i = \frac{S_1 \times R_1 + S_2 \times R_2}{S}$

According to Formula 4 and Formula 5, Formula 6 can be obtained.

Formula 6:

$$\frac{S_1 \times R_1 + S_2 \times R_2}{S} = r_l + \left\lfloor \frac{(B_j - b_l) \times n}{b_u - b_l} + 1 \right\rfloor \times \frac{r_u - r_l}{n}$$

Finally, the optimal resolution for non-MUA region is obtained:

Formula 7:

$$R_2 = \frac{S \times (r_l + \left\lfloor \frac{(B_j - b_l) \times n}{b_u - b_l} + 1 \right\rfloor \times \frac{r_u - r_l}{n}) - S_1 \times R_1}{S_2}$$

For example, assume that maximum resolution r_u is 2040 and minimum resolution r_l is 200. Wireless network bandwidth fluctuates between 10Kb/s and 100Kb/s, that is b_l=10Kb/s, b_u=100Kb/s. The image area S is 20cm^2. MUR area is 6cm^2, its resolution is 2040. Non-MUA area is 14cm^2. According to Formula 7, the optimal resolution for non-MUA region can be obtained at the time of the current network bandwidth of 50Kb/s. When n is 10, R_2 is 738. When n is 20, R_2 is 564.

This optimal resolution is theoretically optimal. In the actual transmission process, the optimal resolution also needs to be further optimized. The optimization is mainly to consider two factors, screen resolution and remaining battery power.

The screen resolution supported by mobile terminal is limited, and the resolution is too high to have no practical significance. Assuming that screen resolution of the mobile terminal is R_t, then the optimal resolution should be less than or equal to R_t.

The battery power has always been the bottleneck of a variety of mobile terminals. In order to better meet the needs of users in the case of limited battery power, battery power of mobile terminal is the most important factor to select the optimal resolution. The battery power of 100mAh can transmit about 50 images. The size of each image is 10MB. And each basic diagnostic process requires access to about 10 medical images requiring at least 20mAh. When the power is less than 20mAh, the resolution needs to be reduced. The resolution of R_p can be calculated according to Formula 8, where parameter P is the remaining battery power, b is the image bit depth.

Figure 8: $R_p = \frac{4M \times P}{b}$, M=1024*1024

The optimal resolution of the medical image should be less than or equal to Rp.

Medical image transmission strategy based on bandwidth sensitivity and multi-resolution considers three factors, screen resolution, battery power and network bandwidth to calculate the optimal transmission resolution. A replica of image block with the optimal transmission resolution is selected as the transfer object.

III. EXPERIMENTS

Medical image transmission system includes clients and servers in mobile environment. Use Android SDK and Eclipse to develop the client. The client can run on all the mobile communication terminals that support Android operating system. The background is made up of 30 System X3400 IBM servers.

Data set is collected from medical image database of North Carolina State University. In order to test the effectiveness of the system for different types of medical images, medical images are divided into three groups according to the organizations, lung, leg and heart. According to the different medical image format, each type of image is divided into X ray image, CT image, MRI image. In the pretreatment process, the single medical image is normalized to 1, 3, 5, 10, 50 and 100MB.

TABLE 1 INFLUENCE OF NETWORK BANDWIDTH ON OPTIMAL RESOLUTION

network bandwidth(Kb/s)	optimal resolution

200	320×320
400	480×480
600	768×768
800	1080×1080
1000	2040×2040

Table 1 shows the relationship between network bandwidth and optimal resolution, when battery power is 1000mAh, the maximum screen resolution is 2040×2040, and the number of sections is 10. As can be seen from Table 1, with the increase of network bandwidth, the optimal resolution also increases.

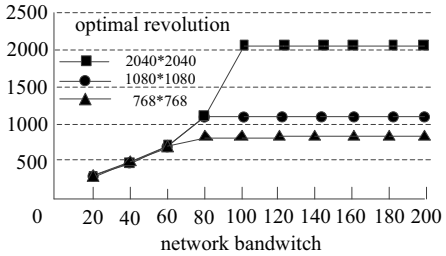

Fig.1. Influence of screen resolution on optimal resolution.

When battery power is 1000mAh, the number of sections is 10. Figure 1 shows the relationship between screen resolution and optimal resolution. With the increase of network bandwidth, optimal resolution also increases. However optimal resolution doesn't increase infinitely, but tends to be a stable value. This is related to screen resolution of the mobile terminal. As screen resolution of mobile terminal is limited, so image resolution is too high to have no practical significance.

TABLE 2 EFFECT OF BATTERY POWER ON OPTIMAL RESOLUTION

battery power(mAh)	**optimal resolution**
5	240×240
10	400×400
15	480×480
20	640×640
25	640×640

Table 2 shows the relationship between power consumption and optimal resolution, when screen resolution is 2040×2040, the number of sections is 10 and network bandwidth is 50Kbit/s. As can be seen from Table 2, with the increase of the power, the optimal resolution also increases.

The efficiency of the strategy is mainly considered from two aspects, transmission cost, and transmission time.

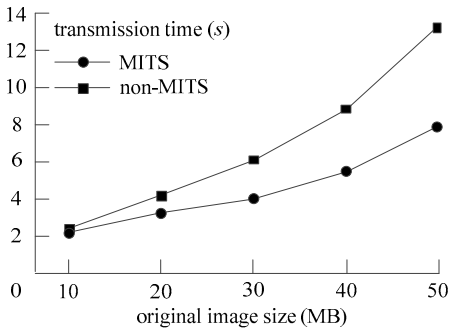

Fig. 2. Relationship between transmission time and original image size

Figure 2 shows the line graph of required time when the strategy MITS and non-MITS strategy transmit the same medical image. The average network bandwidth is 4Mbit/s. Transmission time of the strategy is significantly less than the time of non-MITS strategy.

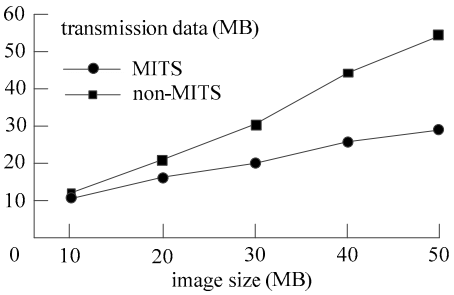

Fig. 3. Relationship between transmission data and image size

Figure 3 shows the relationship between transmission data and image size, when transmitting the same medical image, the actual data transmitted by the strategy MITS is smaller than that of non-MITS strategy. The optimal resolution will change with network bandwidth. When network bandwidth is small, a low resolution image is selected to reduce actual transmission data.

IV. CONCLUSIONS

In this paper, we propose a medical image transmission strategy based on bandwidth sensitivity and multi-resolution. According to network bandwidth, battery power, screen resolution, the strategy would select image replica with optimal resolution as the transfer object. Experiments show that the strategy is effective.

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