Development of “i-Stroke”, a Support System Using a Smartphone for Diagnostic Image Display and Treatment of Stroke

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Abstract

Use of smartphones like the iPhone is rapidly expanding in the medical field. The main reason that use of such smartphones is expanding in the medical field is that ubiquity of smartphones would address certain medical emergency demands. Accordingly, we have developed a new smartphone-based support system for diagnostic image display and treatment of strokes as our first solution for emergency medical care. This report presents an overview of its functional characteristics and technical features.

1. Introduction

This is a report on our development carried out under a joint research contract with the Jikei University and the new product developed.

Stroke, a cerebral vascular disease, accounts for about 30% of the serious cases taken to hospitals by ambulance. It is the third leading cause of death in Japan. Patients' survival and recovery depend on how quickly and properly the initial treatment is provided. In the case of cerebral infarction, which accounts for about 60% of stroke cases, development of complications is very likely to be reduced if blood clots are removed within the first several hours, for instance, by administration of recombinant tissue plasminogen activator (rt-PA) or by endovascular treatment. But, that is not always possible. It is difficult for hospitals to have the specialists on duty 24 hours a day. Team approach to emergency medicine and the environment for its spread are required.

The newly developed “i-Stroke” transmits the diagnostic images and treatment information of a stroke patient from the hospital to the smartphones of specialists. The system supports diagnosis and treatment in the hospital by enabling exchange of information necessary for the initial treatment of a stroke. The i-Stroke has various functions to ensure speedy and accurate diagnosis and treatment. They include “Stroke Call” that calls all the registered smartphones simultaneously, “Timeline” that shows all the images and doctors' comments chronologically, “Treatment Support” that calculates the rt-PA dosage and displays contraindications, “3D Image” that increases visibility of endo-cerebrovascular images and “Streaming” that shows images of surgery real time. This report provides an outline of the i-Stroke and its features (Fig. 1).

2. System Configuration, Main Functions and Features

The i-Stroke system consists of the i-Stroke server, smartphones, WiFi access points and VPN router. Doctors can view diagnostic and treatment information on their smartphones inside or outside the hospital. When combined with Fujifilm's medical imaging and information management system (SYNAPSE), i-Stroke transmits diagnostic images stored in the SYNAPSE to smartphones by a simple operation. Transmission security is ensured by the use of IPSec VPN connection, as well as anonymization and automatic deletion of image information (Fig. 2).
2.1 Emergency Call by Stroke Call

When a patient with suspected stroke is taken to a hospital, a doctor on duty can make a Stroke Call to send basic information of the patient to all the registered smartphones of specialists simultaneously. The specialists, on receipt of the Stroke Call, can view the basic information and diagnostic images of the patient on the i-Stroke on their smartphones and give advice or instructions on necessary examinations and treatments to assist diagnosis and therapy until specialists arrive at the hospital (Fig. 3).

2.2 Emergency Log Management by Timeline

The boxes showing diagnostic images, doctors’ comments and treatments on the screen change color over time. It enables all the staff concerned to share chronological records of information on examinations, diagnoses and treatments (Fig. 4).

2.3 Various Image Display

The i-Stroke is capable of displaying medical examination images, such as CT and MRI images. It also has window/level (brightness and contrast) control of the images to improve the visibility of sites of lesions. Other functions are available as optional extras: 3D Image creates 3D images using the basic technology of our SYNAPSE VINCENT and Streaming shows images of surgery real time on remote devices (Fig. 5 and Fig. 6).

2.4 Treatment Support for Cerebral Vascular Diseases

Treatment Support assists emergency treatment of cerebral vascular diseases. This function provides rt-PA dosage calculation, absolute and relative contraindication check and National Institutes of Health Stroke Scale (NIHSS) check (Fig. 7).
2.5 Coordination between Hospitals

When a patient is transferred from one hospital to another, if both hospitals use this system, the flow of transfer from request to acceptance will be facilitated by the system. The Timeline information, such as diagnostic images and treatment information of the patient, are transmitted to the receiving hospital. The information on the patient is viewed on the system and acceptance is notified by the system. That leads to speedy diagnosis and therapy (Fig. 8).

3. Technical Features

3.1 Compression of Diagnostic Images and Download

The server reduces the data size of a diagnostic image to suit a receiving terminal, for instance, it changes the size of an image and compresses the image file by format conversion. The data size is made small enough before sent to a smartphone. That shrinks time required for image transmission and increases the speed of operations on the received image. Once an image has been downloaded, no data communications is required and only required is the internal processing of the smartphone. That enables high-speed highly-functional image viewing (Tables 1, 2 and 3).

Table 1  Image file data size (Dicom Raw and i-Stroke data).

<table>
<thead>
<tr>
<th>Modality</th>
<th>DICOM Image Data Per 1 Exam.</th>
<th>i-Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Image Count</td>
<td>Matrix</td>
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<tr>
<td>CT</td>
<td>175</td>
<td>512×512</td>
</tr>
<tr>
<td>MR</td>
<td>95</td>
<td>512×512</td>
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<tr>
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<td>398</td>
<td>512×512</td>
</tr>
<tr>
<td>3D Image</td>
<td>240</td>
<td>512×512</td>
</tr>
</tbody>
</table>

3.2 Tight Security

As an encryption system for communications, we employ the IPSec VPN system. This system is specified in the guidelines for security management of medical information systems established by the Ministry of Health, Labor and Welfare. For device authentication, we use device ID registration and authentication. Furthermore, personal information is protected by anonymization. Automatic deletion of data in each terminal is also available.

3.3 3D Image Creation and Display

3D images are created using the SYNAPSE VINCENT as a rendering engine. We have developed a plug-in of the SYNAPSE VINCENT to request for 3D image creation and receive the parameters. The plug-in for the i-Stroke receives a request from a terminal via the web service, renders the image with volume rendering (VR) or maximum intensity projection (MIP) and returns the 3D image (Fig. 9).

In order to rotate a VR 3D image freely and quickly on a terminal, the terminal must have a series of images in all angles, like a flip book, downloaded. The images are rotated vertically, horizontally and obliquely from the position where the positive side of each coordinate axis faces the front. This is to ensure that an image appears to rotate in the direction intended by operation on the terminal. For example, this is to prevent an image from turning in the wrong direction when it is to be rotated up or down after it has been turned 180 degrees to the right or left or to prevent an image from twisting when it is turned obliquely (Fig. 10).
An MIP image is not created from all the original images. An MIP image is created from the thickness of the original images and increments in position and the images in sagittal, coronal and axial orientations are simultaneously created. That saves some operations, such as clipping (Fig. 11).

3.4 Streaming in Wide Application

We use the most common and most widely used video signals as the input resource and thus they can be used in operating rooms and various other facilities. A video signal is encoded to MPEG4 (H264) codec and transmitted to the server real time with the RTSP protocol. The signal is broken up on the server and sent to a terminal after the protocol has been converted to HTTP Live Streaming or any other protocol suitable for the terminal (Fig. 12).

4. Conclusion

The report has provided the outline, functional features and summary of development (technological features) of the support system using a smartphone for diagnostic image display and treatment of stroke, i-Stroke. We believe that it is the best system available at present that helps hospitals suffering doctor shortage and that enables doctors to participate in medical practice anytime anywhere.

We will continue to work on this system to expand its functions to support emergency care of many other diseases. We seek to provide systems that help enhance quality of medical care, maintain and improve people’s health by beefing up the support of emergency medicine.

5. Acknowledgements

We would like to thank Professor Murayama and Dr. Takao at Department of Neurosurgery, Jikei University School of Medicine for providing us with the opportunity to do this research and valuable guidance. Especially, we appreciate Dr. Takao’s help from beginning to end in the implementation.

References

1) The rt-PA (alteplase) intravenous therapy guideline subcommittee, the medical care improvement and social insurance committee, the Japan Stroke Society. Guidelines for rt-PA (alteplase) intravenous therapy, October 2005.

(In this report, “WiFi” is a registered trademark of Wi-Fi Alliance. “i-Stroke”, “SYNAPSE”, and “VINCENT” are the registered trademarks of FUJIFILM Corporation.)