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Ultrasound Image Storage on Raspberry Pi as a Basic Data Transmission

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ABSTRACT Ultrasonography (USG) is an examination technique as one of the diagnostic aids in primary health facilities, including community health centers. With the availability of USG services, it certainly makes it easier for the public to get faster health screening and monitoring. To minimize the disparity between the number of doctors and the number of health facilities, a telemedicine system can be utilized to make services more efficient. This study aims to design an ultrasonography (USG) image storage system that utilizes Raspberry Pi as a storage medium and ensures the delivery of USG images without image loss, thus supporting the development of a telemedicine system to improve the efficiency of health services. The study was conducted using Raspberry Pi as a storage medium for USG images. Image data was tested by sending and reopening files on another computer to ensure that the USB storage function on the Raspberry Pi worked properly. This process involves measuring the level of image data loss during transmission. The results showed that there was no loss of USG image data during saving process, with an error rate of 0%. This confirms that the designed system can maintain the integrity of USG image data well. The Raspberry Pi-based USG image storage system has been proven to be able to store image without losing any image. This module can be the basis for further development in the delivery of ultrasound images through the module and send it online directly that can support more efficient distribution of health services

INDEX TERMS Telemedicine, Tele-Ultrasonography, USG Image, USB

I. INTRODUCTION

Along with the improvement of technology in various aspects, including the health sector, the Ministry of Health in the "Public Health Program Action Plan 2020-2024" has formulated a policy direction that refers to the 6 pillars of health transformation, one of which is the transformation of primary services [1]. This effort is made to provide easy access to health services in order to improve the level of public health. Based on the "Ministry of Health's National Priority Program", the improvement of reproductive health services is also given great attention. This is indicated by the government's commitment to providing medical devices such as USG in primary health facilities, including health centers [2]. With these services, it is certainly easier for the public to get faster health screening and monitoring. It is hoped that efforts to increase these services can not only be utilized by pregnant women, but by all levels of society to carry out health screening [3].

Telemedicine that can be developed in the health sector is when there is a need for consultation between health workers at primary health facilities with more expert consultants [4]. Telemedicine or telemedicine services according to WHO have four elements, namely: (1) Aim to provide clinical support; (2) Intends to overcome geographical barriers between users who are not physically in the same place; (3) Involves the use of various types of technological equipment; (4) Has an end result for improving health levels [5]. In Indonesia, one of the problems that overshadows the equal distribution of health services is the lack of health human resources [6]. In fact, in Indonesia, ultrasound examinations and screenings can be carried out by general practitioners, because it is one of the competencies that must be possessed [7]. So with this tele-USG system, health facilities that do not have specialist doctors can send the results of the patient's ultrasound examination by the doctor on duty to carry out further diagnosis if necessary, thereby accelerating services [8]. For the implementation of telemedicine in Indonesia, Makassar is one of the areas that has actively implemented this system, including tele-USG and tele-ECG, since it was developed in 2014 [9], [10]. However, sending image data is still done manually and offline and then needs to be uploaded using a separate application. In previous studies, several tele-USGs have been developed that can send ultrasound images /

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videos remotely [11]. Mehdi Ahmadi et al., conducted a study by taking live video from USG then sending it via a local network along with a video of the probe's movement when taking pictures using an external camera, then the results can be viewed via a tablet [12]. The study was continued by Zhang Young, et al. who made the results of streaming video able to be sent via the internet network [13]. By utilizing technological developments, acquisition and transfer of video/image output can be done using Raspberry Pi [14], [15]. From these studies, one of the problems that arises is data transmission. Because the data sent is in the form of a video with a large capacity, a network that has a high connection is needed to send video results that have a quality close to the original. In addition, sending images or videos is done manually using cables and there is no analysis that proves that the images or videos do not experience data changes or decreased image quality. From the results of the image data transfer, image quality also decreases when encrypted. For this reason, the author plans to create an image storage media from USG directly using Raspberry, so that in the future it can be developed again to support image delivery on simple tele-USG without having to move the image via disk, cable, or USB first so that it can optimize time efficiency to provide services to patients in need. It is also hoped that this will minimize the costs required to procure more complex tele-USG supporting equipment. This article is only a basic research to achieve that, in how Raspberry works to store image from USG and see if there loss image data that have been saved directly to the module.

II. METHODOLOGY

This research was conducted at the Diagnostic Laboratory of the Department of Electromedical Technology, Surabaya. The research design used was the pre-experimental design method with a one-group pretest-posttest design research type by comparing the results after treatment and before treatment. The results obtained were not through measurement, but by looking at the results of the comparison of the groups tested. At this stage, the author uses Raspberry as an external data storage from ultrasound. The stored ultrasound data image can be used for the next development process.

This paragraph explains FIGURE 1 Ultrasound Image Storage Block Diagram, where the Raspberry work system is to receive image input that has been exported from the ultrasound device. Then the results of the image storage are opened on a personal computer to ensure that the stored data is correct.

Referring to FIGURE 2 Ultrasound Image Storage Flow Diagram, when the device is turned on, it will immediately initialize the Raspberry. When the ultrasound image is saved to the Raspberry, the USB function is active and will save the image. After that, connect the Raspberry to the PC to see if the stored data matches the exported data.

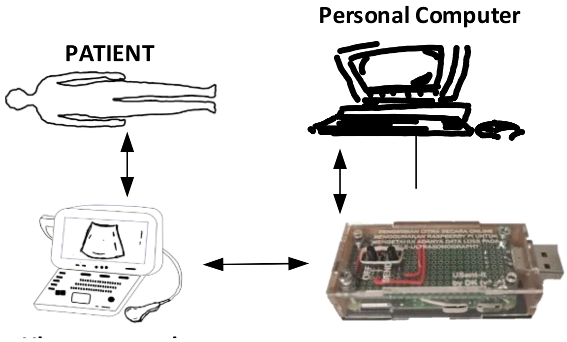

FIGURE 1 USG Image Storage Block Diagram

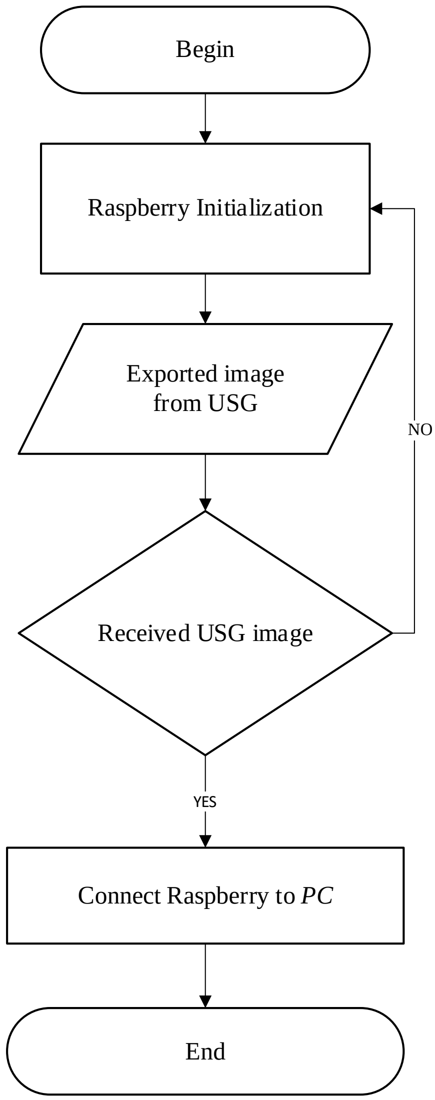

FIGURE 1 USG Image Storage Flowchart

A. DATA ANALYSIS

This study does not use measurements, but with physical examination with vision to see the comparison of the number of USG images that have been stored. As a calculation, the calculation of the error value of the image received on

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Raspberry against the image exported from USG is used. The calculation used is as follows:

$$\%\text{error} = \frac{(xn - x)}{xn} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where xn is the number of exported images from the USG and x is the image received by the Raspberry Pi.

III. RESULT

The results of the module are shown in FIGURE 3 below.

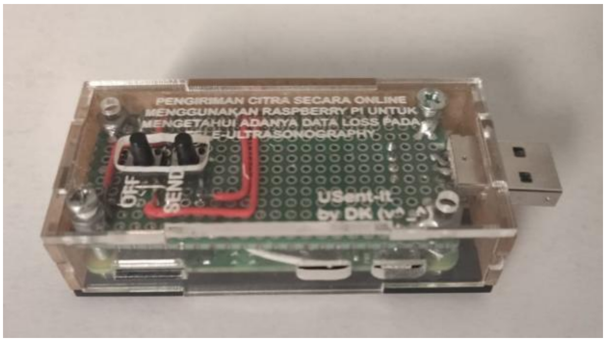

FIGURE 3. **USG Image Storage Module**

The module developed in this study includes components in the form of a series of push buttons and a USB type A port, which functions as the main input to the Raspberry Pi device. The USB type A port is designed to be connected directly to the Ultrasonography (USG) device, so that the Raspberry Pi can function as an external data storage medium for the device. The stored data comes from the export of USG images, which are then further analyzed.

The data collection process was carried out at the Surabaya Electromedical Technology Diagnostic Laboratory using 2D USG images as research samples. The "smart USB" feature on the Raspberry Pi is optimally utilized to handle this data storage, allowing the Raspberry Pi to receive, store, and manage export files from the USG device efficiently. This system aims to ensure that the stored medical images are of good quality without losing data, supporting accurate and reliable diagnostic needs.

The following is one of the results of storing USG images (FIGURE 4) on Raspberry that has been added with USB function:

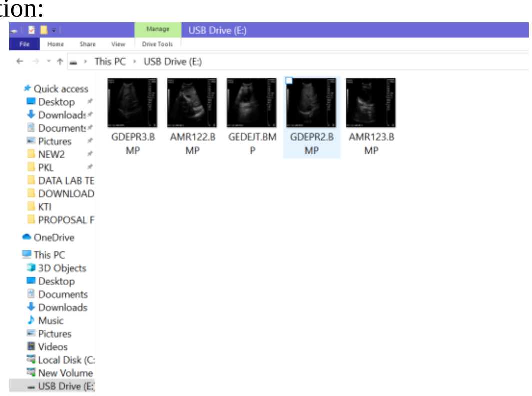

FIGURE 4. **USG Image Storage Results on Raspberry**

The results of image data collection can be seen in the graph (FIGURE 5) below:

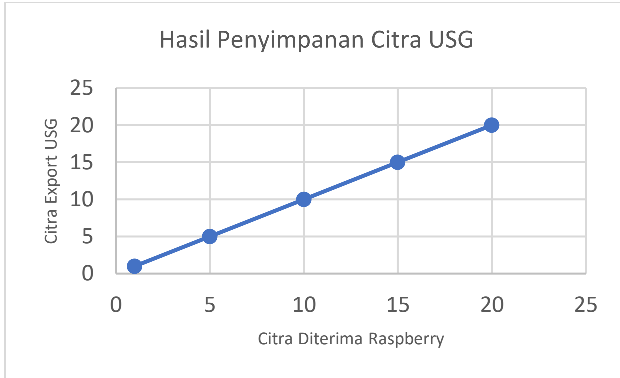

FIGURE 5. **USG Image Storage Results Graph**

From the image above, it can be seen that the number of USG images exported from USG When opened on a PC, the same number of images are obtained. This means that no USG images are lost during storage. So the results are obtained if Raspberry can be used as a data storage medium on the USG device

V. DISCUSSION

This study tested Raspberry Pi as a storage medium for ultrasound images with a step-by-step scenario (1, 5, 10, 15, and 10 images). The results showed 0% error, ensuring no image loss during storage or transfer.

Comparison with Similar Research, namely: Cable-based: Transfer cables are effective but limited by cable length and the need for additional devices, while Raspberry Pi is more portable and flexible. LAN/Wi-Fi-based: LAN/Wi-Fi transfer is fast but prone to data loss; Raspberry Pi secures data before transfer.

Cloud-based: Cloud provides broad access but relies on the internet, while Raspberry Pi offers an affordable local solution.

The implications of the study are: Raspberry Pi supports operational efficiency, lossless image access, and potential integration with network-based or cloud systems, and is useful for health facilities in remote areas.

And the direction of further research is sending image directly, integration with the cloud for hybrid systems, increasing data security with encryption, large-scale testing to assess long-term reliability and compatibility testing with other medical devices such as ECG and CT scans..

V. CONCLUSION

This study aims to develop a Phonocardiography (PCG) system that can combine S1 and S2 peak detection for heart rate estimation in the context of rule-based methods. Real-time PCG-based detection systems for arrhythmia monitoring are still limited, and there is a need for efficient algorithms with low computational requirements. The availability of PCG data

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is also a challenge in evaluating existing methods. This system aims to improve the accuracy of arrhythmia classification, improve response time, and reduce human intervention in diagnosis, thereby supporting cardiologists in making more informed decisions. The HR module has demonstrated high accuracy in detecting heart rate in tachycardia, normal, and bradycardia conditions, with errors ranging from 0% to 4.1%. Measurement results on mannequins and patients show little difference between the HR module and the reference standard. The rule-based threshold system can identify S1 and S2 heart sounds and calculate their intervals, effective for early detection of arrhythmias in real time. The next work of this research is system needs to be developed for integration with remote monitoring, thus enabling real-time monitoring of patients and improving the quality of care.

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