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A PDA-BASED TELEPROCESSING SYSTEM

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Abstract. *Personal Digital Assistant (PDA) handheld devices have proven to be valuable medical teleconsultation tools within a hospital environment. Nevertheless, the limited CPU capability of these devices constitutes a major drawback when computationally demanding algorithms are employed. For the purposes of this study, PDA application software was developed, using Java, for connecting a PDA device (Compaq iPaq 3630) to a network of Processing Units (PUs) via IEEE 802.11b compliant wireless card. Each PU received several parts of an image, which were then processed by applying the Adaptive Weighted Median Filter (AWMF), an effective but computationally demanding speckle suppression algorithm. The processed fragments of the image were next sent back to the PDA, where the final enhanced image was reconstructed and displayed*

1 INTRODUCTION

Nowadays, the small size and weight of PDA devices offer extreme portability and convenience. Moreover, with the rapid evolution of electronic technology, PDAs are now capable of accomplishing demanding tasks, such as reproduction of video sequences and processing of static high quality medical images[1]. In addition, PDAs are also capable of connecting to wired and wireless networks and take full advantage of their potentials. A wide variety of applications, including medical imaging, exploit wireless local area network technology. The reasons behind the vast popularity of WLAN-related applications are mostly associated to increased portability as opposed to the case of wired LANs.

Furthermore, modern PDA handheld devices, combined with wireless networking technology and image processing techniques, can be used for modern medical teleconsultation within a hospital environment[2]. However the limited CPU capability of PDA devices constitutes a major drawback when computationally demanding algorithms are employed.

In the present study a solution to the aforementioned limitation of the handheld devices is introduced. The solution proposes the distribution of the processes involved in a computationally demanding routine over a network of Processing Units (PUs). The algorithm used was the Adaptive Weighted Median Filter (AWMF), which is an effective but computationally intensive speckle suppression algorithm[3].

2 MATERIALS AND METHODS

Two distinct software applications were developed in Java language following the server-client model. The server-side application was designed to run on a PDA and was responsible for distributing the processing tasks over a network of PUs. The client-side application was designed to run on every PU and was in charge of executing the processing tasks assigned by the server [Figure 1].

Both the PDA's and the PU's software were developed in MEDISP (Medical Image and Signal Processing) Lab of Technological Institute of Athens. The software packages used for developing the final application included:

- Eclipse Integrated Development Environment (IDE)[10] and Java Development Kit (JDK) version 1.1.8
- Creme Java Virtual Machine for Pocket PC 2002 edition

The applications were developed on a typical desktop PC (Intel Pentium 4 / 2.6GHz with 1GB RAM) running Microsoft Windows XP Professional.

The PDA device chosen for the final prototype was the Compaq iPaq 3630 combined with D – Link IEEE 802.11b compliant wireless card DCF-660W. The device features a 200MHz Intel Strong-Arm Processor, 32 MB SDRAM, 16 MB Flash ROM, a Compact Flash Card expansion slot for optionally adding extended memory capabilities and a 3.8" 240x320 16-bit color TFT display with backlight. The operating system was the Microsoft Pocket PC 2002. The PUs were also typical desktop PCs similar to the one used for development of the applications.

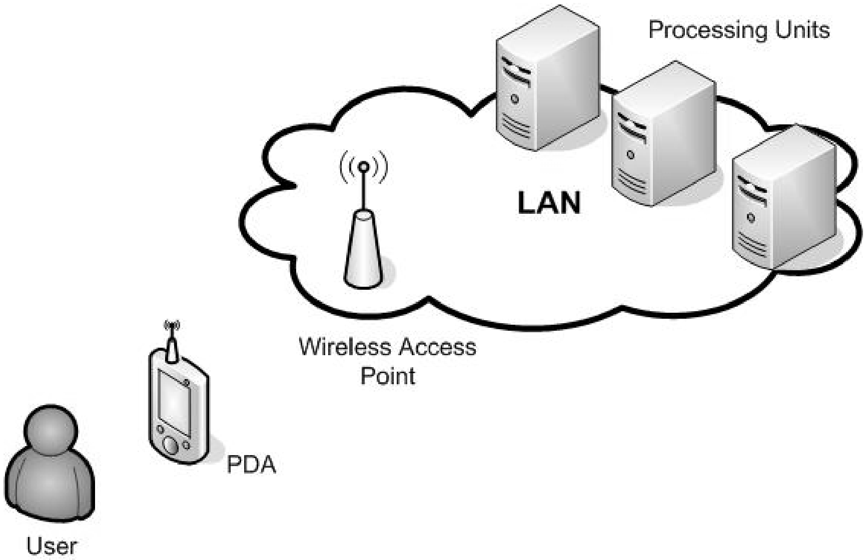

Figure 1. Basic scheme of the system's architecture

The PDA application can open a variety of images (color or grayscale) of the following formats: BMP, JPG, GIF, PNG and TIFF. It can also save the opened images in BMP, JPG and GIF format. It can open practically any size of image, but the application's maximum visible resolution is limited to a frame of 180x180 pixels. Images that exceed this size can also be viewed employing the appropriate zoom factor so that the original image fits in that frame.

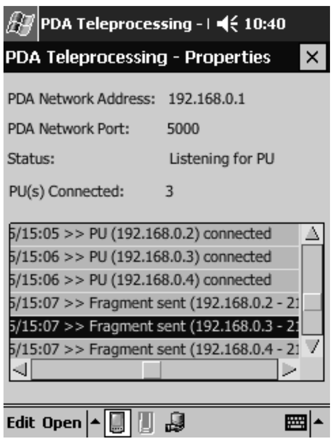

Figure 2. Server-side application running on a PDA

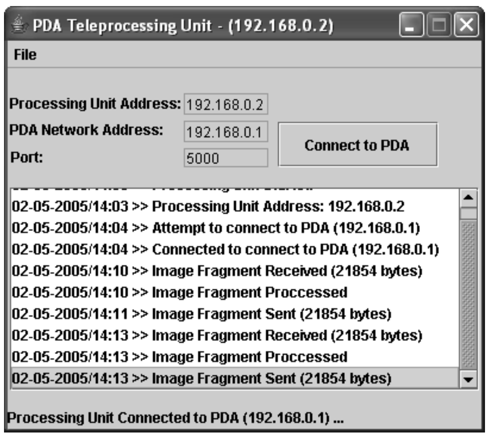

Figure 3. Client-side application running on a PU

Once the server application starts several PUs can connect waiting for processing tasks to be submitted

[Figure 2]. The application can then divide the loaded image into distinct parts and distribute them to the PUs taking full advantage of the wireless networking card. On client side, every application running on each PU receives a unique image fragment, processes it and sends the processed image fragment back to the server [Figure 3]. The server collects all the processed image fragments, joins them, and reconstructs the final processed image. Finally, the server application delivers the enhanced image to the screen of the PDA [Figure 4]. In case that no PU is connected to the server application, the whole image processing algorithm is carried out exclusively by the PDA. All transferred data between the server and the client follow a custom XML-based form for interoperability purposes[4].

The algorithm used on the client-side was the Adaptive Weighted Median Filter (AWMF) introduced by Loupas et al[3]. The selection of this algorithm was based on the criterion of the computational power it requires. In particular, using the information acquired by the local first order statistics (variance-to-mean ratio), it performs a spatially adaptive median filtering in a square kernel by means of adjusted pixel values. The pixels are adjusted using a centroid kernel that is calculated by Equation 1 as a windowing function similar to the triangular window:

$$w_{X,Y} = \left[w_{X_o,Y_o} - g\sqrt{\left(\left(X - X_0\right)^2 + \left(Y - Y_0\right)^2\right)}.\frac{\sigma^2}{\mu} \right] \quad (1)$$

where, $w_{X,Y}$ denotes the value of the weight window at position (X, Y), $w_{Xo,Yo}$ the center weight value, σ the standard deviation, μ the mean value and g is a scaling factor. The weighted window values, $w_{X,Y}$ calculated by Equation 1 are then used for typical median filtering, replacing the center window pixel value by the median value of the weighted area. Optimal kernel size and coefficients were evaluated through iterative experiments, while W_0 has been determined theoretically[5][6]. The final values calculated for the best AWMF are illustrated in Table 1.

Parameter	W_0	g	Kernel Size
Value	99	7.5	9x9

Table 1 : AWMF parameter values

3 RESULTS

Portable, small weighted devices, capable of running special purpose applications have been proven to be valuable tools for preliminary diagnostic evaluation by physicians[2].

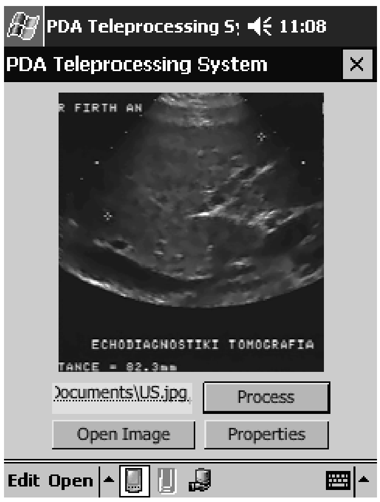

Figure 4. The processed image as
it can be viewed on the PDA

The overall processing time was substantially decreased by the use of multiple PUs, as compared to the corresponding processing time achieved by a single PDA. In particular, the processing time depended on the number of processing units utilised and can be further diminished with the use of additional PUs. Employing three PUs the processing time for despeckling of a 256x256 gray-scale ultrasound image was about 10 seconds (including transfer time from PDA to PU network and vise-versa) as opposed to 250 seconds of the PDA's corresponding processing time. Furthermore, the integration of new generation wireless network technologies, such as IEEE 802.11g (55Mbps) instead of 802.11b (11Mbps), can further improve the transfer speed.

Additionally the use of Java and XML renders the system platform independent[9]. Moreover the system is designed in such a way that other computationally demanding algorithms can be easily integrated.

4 CONCLUSION

By exploiting state-of-art technology, a PDA-based teleprocessing system was designed and proved helpful for application in a hospital environment. The system combined successfully the portability of a PDA-based teleradiology system with the processing power provided by a computer network.

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