Optimization for Video and Telebotic Control on Palm OS PDAs

Alexander Ferworn Wei Lu

Network-Centric Applied Research Team
School of Computer Science
Ryerson University
350 Victoria St, Toronto, ON
Canada

ABSTRACT

The Network-Centric Applied Research Team (NCART) [1] has been exploring the possibility of extending video, audio and control services through the Internet to various telebotic devices. To allow greater freedom of movement to the telerobot, the final communications link is wireless. In previous work, we have demonstrated a wireless client interface through a common Palm OS Personal Digital Assistant (PDA).

Wireless Internet Video and Robotics Control on the Palm OS PDA involves the problem of multiple constraints, including limited bandwidth, hardware speed and software size. This paper presents solving the problem numerically by means of a Simplex Technique. Some numerical results are presented.

KEYWORDS:

Optimization, Simplex, Low-Bandwidth Video, Robotics Control.

1 INTRODUCTION

As PDAs become ever more popular, they are also quickly acquiring many of the capabilities available only on much larger desktop computers. With wireless Internet connection widely available to PDAs, many people can use PDAs as a computer or laptop replacement [2].

Our research revolves around developing concepts that focus on a PDA's size to allow for novel functionality [3]. We have developed techniques to allow streaming video to be sent to a PDA and, in turn, allow the PDA to send control signals to the video source [4]. Both control and video signals are wireless. For the purposes of this work we use Palm-Compatible PDAs. The video source we use and control is sent from an Internet-enabled wireless video telerobot called MAX [5]. The robot has a public interface and can be controlled via the WWW by visiting [6].

There are various possible applications for this research as many researchers and manufacturers have suggested including hand-held surveillance systems, bomb removal video and control, rescue robots, video-conferencing, controlling of home or office appliances, etc. For more information about some of these areas see[7][8][9][10].

However, streaming video and robotics control often require broadband connection speeds on the order of 10 MBS or greater to be effective. We have successfully built a prototype low-bandwidth remote video and robotics control Palm client that is capable of stream 5 frames a second at 14.4 KBS. To make this application effective, we need to calculate the largest possible video size with the available bandwidth.

2 THE STUDY

For image recognition and other image processing tasks [11], the image size and quality is crucial. With a bigger image size, an image-

rendering engine is able to provide more detailed and therefore better quality interpretations and images.

We use a Palm Pilot IIIxe as a reference PDA running the Palm Operating System [12]. We will refer IIIxe as the PDA throughout this paper. The PDA's hardware consists of:

- CPU: 13Mhz Motorola Dragonball
- Screen Size: 160x160 pixels
- Color: Grayscale
- Programmable Memory: 128K

The current generation of wireless Internet bandwidth for PDAs like the Palm is limited to 14.4 KBS--a very slow speed when compared with 10/100Mbps on LAN-based laptop and desktop PCs. Given such a large bandwidth constraint, it is unrealistic to use colour images while expecting an acceptable frame rate. We have defined the acceptable frame rate to be at least five frames per second on the Palm. This allows for a stop-action affect that can be interpreted rather easily by a casual observer.

To reduce the complexity of the problem, we use 1-bit color depth -- black and white. Therefore:

1 pixel = 1bit data

Each pixel contains either black or white, which are represented by one and zero. We have a total of 14400 bits per sec (14.4 KBPS) bandwidth available. Based on empirical observation we developed a heuristic that allocates 400 bytes for the transmission of control data as well as the network delay. Therefore the bandwidth available for video is 14000 BPS.

3 FIXED CONSTRAINTS

To simplify this experiment, we assumed the CPU and the network delay are constants. This is not necessarily true in our lab's environment but is probably safe to assume in a commercial fee-for-service environment.

In addition we lived within the constraints of programmable memory for all Palm-Compatible PDAs at the time of writing. While this constraint will undoubtedly be removed, we believe there will always be devices that require similar functionality with limited resources--cell phones for example.

4 THE PROBLEM

Let V represent the video size on the Palm, S the maximum screen size and B the Bandwidth. The problem can be presented as an optimization problem for the Simplex Technique:

Find Maximum video size V:
V = S
Where
S = Screen Size and B = Bandwidth
Subject to:
S <= 160, B <= 14000, B/S/S <= 5, S>0, B>0

B/S/S is the frame rate. We can solve this problem using any standard math packages such as MatLab, Maple or Excel. For this experiment, we choose Excel.

We were looking for the maximum possible value in video size given the constraints we have outlined. This maximum video size was calculated as 53 pixels per square size.

	A	B	C	D
1	**Optimize Video Size**			
2				
3	**Type**	**Unit**	**Value**	**Formula**
4	Bandwidth	pixel/sec	14000	
5	Screen	pixel	53	
6	Frame Rate	per sec	5.00	C4/C5/C5
7				
8	**Video Size**	pixel	53	C5

5 PRELIMINARY RESULTS

When we ran the experiment with the original video size of 48x48, the frame rate was sustained as 5 fps. With video size increased to 53x53, as expected, the frame rate was still stable at 5 fps. The original image is presented

below as captured the Palm emulation software. The image is that of a window in the lab where the camera is located.

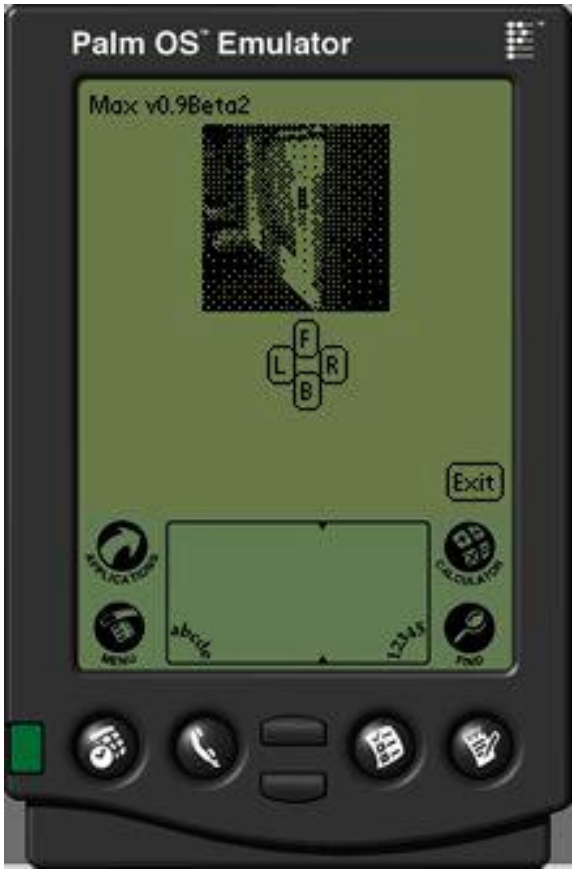

Figure 1 Original Video Application

By providing a larger image, objects became easier to distinguish. The figure below demonstrates the improvement in image quality based on window resizing. The image on the left is the image as captured by the video camera. The image on the right would be displayed on the Palm.

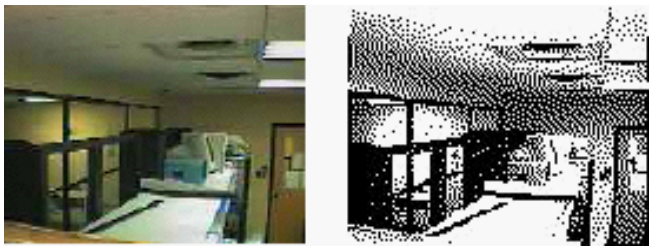

Figure 2 Original vs. Palm Image

6 CONCLUSION AND FUTURE WORK

By using the Simplex Technique, we have demonstrated the ability to produce optimal sizing for video images on a limited bandwidth device without affecting the frame rate achievable. The resulting image is able to contain more information aiding individual users in determining what is being represented by the image. In addition, the image can be used to automatically recognize certain features within it. We have are currently using the streamed PDA images as the basis for recognizing handicapped access buttons to aid the traversal of passageways by an indoor mobile robot.

When better PDA and wireless technologies are available, or when we have more detailed constraints such as consistent network delays, we should be able to use this method to provide optimal screen image size.

6 REFERENCES

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