CS848a Project Proposal:
Tagging Technology for the Masses

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Overview

The concept of tagging technology is not a new one [2]. Researchers have been experimenting with different tagging technologies for years. Their attempts included RFID tagging, barcodes, Infrared tags and others. These tags represent a key milestone for pervasive computing: The ability to extract information about the surrounding environment. However, for pervasive computing to truly become a reality, it must be provided to the masses. As of this time, no commonly available PDAs or other hand held devices come standard with a bar code or RFID reader, and this is where tagging technology fails.

As a proposed solution, we will attempt to build a machine-readable image that can be produced with a conventional laser or ink-jet printer, and is readable by a camera phone, or camera equipped PDA. This will enable us to conquer the problems of cost and availability. Both the technology to produce, and scan these bar code like images is commonplace today.

The goal of this project is to prototype a system that uses barcode-like icons to embed information into static images (like posters, etc.), which can be decoded with a standard camera-phone or PDA (with camera). The data encoded in the icon will contain a URL and object ID. The cellular or wireless data network will be used to retrieve extra information based on the URL and object ID.

Wireless networking is also very common and most North American cellular phone providers also offer WAP enabled products and WAP access to the Internet. PDAs are equipped with wireless access though such protocols as 802.11b or Bluetooth. This system will take advantage of this wide spread technology.

Alternative Forms of Input

For many pervasive computing devices, standard keyboard input is an inelegant solution as their size and their usual mode of use does not allow for smooth transfer of the QWERTY keyboard paradigm. Cell phones and PDAs are obvious examples of this. Typing a URL on most cellular phones requires far more time and keystrokes than on a PC. For example, typing in even a simple URL such as www.bbc.co.uk on a cell phone requires upwards of 20 keystrokes. PDAs are generally either equipped with a small QWERTY keyboard that can be somewhat difficult to use because of the size of the buttons, or require the user to input the URL via a touch sensitive screen in a somewhat tiresome fashion. The solution of using a camera as input would require the user to simply start an application and click a single button to take a picture of an icon. If the application is used frequently enough, it could be easily connected to a 'hot-button' on the device.

Previously proposed methods of data input include traditional ISBN barcode readers. Barcodes are a tightly regulated standard of information representation and require specialized hardware to read the data. Barcode readers, though easy to use, are not a form of technology widely available to the average cell phone and PDA user and, at least for

the time being, are not likely to become a popular option on these devices. Another input method, often touted by researchers, is the use of RF tags, however these are expensive to deploy, and the scanning technology is not commonplace.

Existing Work

The following two papers sparked our interest in tagging technologies. The first paper [1] discusses approaches to tagging mentioned elsewhere in this documented (RFID tags, IR tags, etc.). The second paper [2] talks about a reality where ubiquitous computing is achieved through placement of “tabs” on virtually every item, so information about the items can easily be extracted.

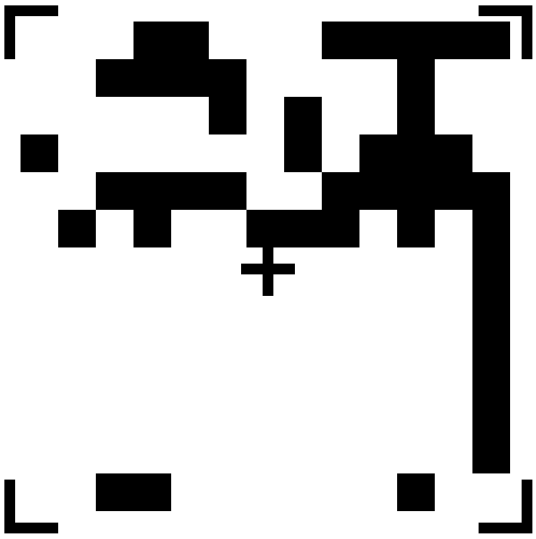
Icon Specification

What we need is a way to encode text data into an image that can be easily extracted. To achieve this, we are going to use a series of dots or squares to form a 2-D barcode that is easily "parsed" or interpreted back into text data.

Our focus is primarily on two options: Black and white icons, and coloured icons. The data will be encoded into the icon using 6-bit ASCII. This will provide us with all alphabetical and numeric characters, as well as a handful of punctuation characters, which can be used as various indicators and include character commonly found in web URLs. The reason for not using full 8-bit characters is to keep the icon small. Data size is a major issue, especially with the black and white icon.

Sample Icons

Black and White Icon:
The black and white icon (13x13) can hold up to 24 6-bit characters worth of data. The first 6 columns hold the first 6-bit character, the second 6 columns hold the second 6-bit character and the last column holds the parity bit. The parity bit is used for error detection (and correction is the number of bit errors is small). The requirement for error correction will become more evident once evaluation of the prototype is complete. We can determine whether we get lots of errors or whether they are errors a rare event. Detecting errors, however, is always a useful feature. Below is a prototype icon. Encoded in the image are 12 characters of data, the checksum bits can be seen along the right column and bottom row.



Coloured Icon:
This table uses 7 colours to make each square represent a 3-bit value. Two 3-bit values put together, give us the required 6-bits for our character set. If we're able to use colour, we immediately triple the capacity of the icon (since each square now represents 3-bits instead of just one). As technology improves, it will be technically possible to add even further refinement to the colour encoding and pack even more data on to an even smaller icon. This is the ultimate goal.

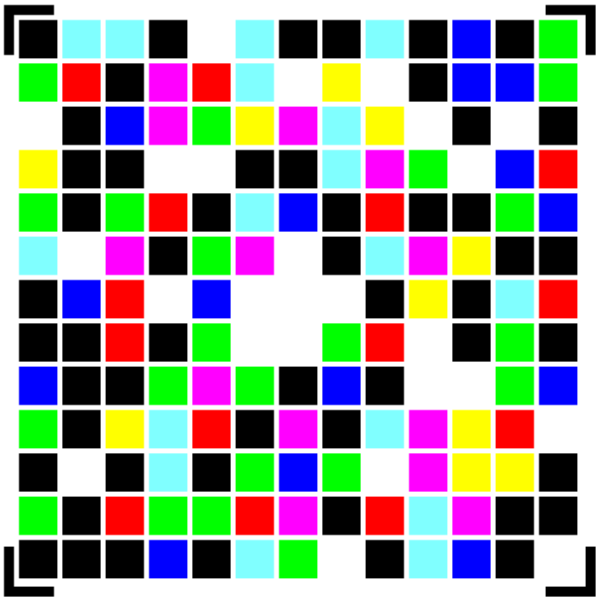


Figure 2 - A sample colour icon (for illustrative purposes only)

Project Risks

The biggest risks of this project surround the camera. We plan to test this system to using a PocketPC with an add-on camera. Unfortunately we cannot determine whether the

image quality will be sufficiently high to acquire the data correctly. We are also wary of the fact that different lighting conditions may have an impact on the accuracy of the data capture. Experimentation will determine whether or not our concern is justified.

It is not clear with what accuracy the user of the camera will have to aim the camera lens. Provisions have been made for reference points on the icons so that the image can be skewed or scaled as necessary. Again experimentation will determine what the tolerance level of skewed perspective the system can handle.

The colour icons also may present a problem, as detecting and differentiating among 7 different colours may require addition research into image processing techniques. It will also present far more difficultly in differing light conditions as detecting the difference between black and white is easier than making a distinction among colours with more similar RGB values.

The relatively small computing power available on portable devices also poses a potential problem. It is expected that any image captured with the device's onboard camera will require some type of image correction (rotation, scaling, etc.) to make the image map correctly back to the template. The calculations required to perform these corrections can be enormous, and may be too complex (in terms of both time and space) for today's handheld devices. If this is the case, some type of offloading of the image analysis will be required, but ideally we would like to do all the work on the handheld.

Also of concern is that neither team member work on this project has previous experience with image analysis. The nature of the imaging used in this system is, however, fairly elementary and should not require significant research to become familiar with.

Assumptions

To keep the project scope in check, we are assuming that the handheld devices will have some type of access to a data network. If the data network is unavailable at the time when the image is read, then the URL and product ID scanned from the object will be buffered until the connection to the data network is restored.

Our prototype will be built on a Compaq iPaq h5550. This will allow us to work with Microsoft's .NET framework for rapid development. We will this will allow us to achieve the most amount of work in the least amount of time. Ideally, we would like to port or re-write the application to run on a Nokia cell phone, but this is strictly optional as we suspect time will not permit it.

Summary

This project's goal is to produce a system allowing cellular phone and PDA users to acquire machine-readable information from their surrounding via their devices' camera. This project will combine elements of image analysis and wireless networking and result in:

- An elegant solution to providing useful and context aware information to mobile device users.
- An easy to use application that takes advantage of a burgeoning trend equipping mobile devices with cameras and requires a single click of a button to input the desired data.

Group Members

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References

1. HP Laboratories, "The Challenges and opportunities of integrating the physical world and networked systems," Mobicom 2001 Challenge Paper
2. Mark Weiser, "The Computer for the Twenty-First Century," Scientific American, pp. 94-10, September 1991.