Exploring Interfaces to Botanical Species Classification

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CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
We have developed several prototype user interfaces for botanical species identification and data collection across a diversity of platforms including Tablet PC, Ultra Mobile PC (UMPC), Apple iPhone, Augmented Reality, and Microsoft Surface. In our demonstration, we show UMPC and iPhone user interfaces, discuss the commonalities and distinctions across the different interfaces, and invite visitors to explore these differences. Our prototypes address several issues of interest to the CHI community including mobile interfaces, interfaces to object recognition, and visualization.

Keywords
Electronic Field Guide, Identification, Mobile User Interfaces, iPhone, Augmented Reality

ACM Classification Keywords
H.5.2 [**Information interfaces and presentation (e.g., HCI)**]: User interfaces—*Graphical user interfaces (GUI)*; H.5.m [**Information interfaces and presentation (e.g., HCI)**]: Miscellaneous.

General Terms
Electronic Field Guide, Identification, Mobile User Interfaces, iPhone, Surface, Augmented Reality

Figure 1. Tablet PC user interface displaying potential matches to the leaf shape.

Figure 2. UMPC user interface with previous matches and live video view.

Introduction

Our well-being is intimately connected with our understanding of the natural world. Yet, botanical species on our planet are disappearing faster than we can identify and study them. Even species already known to science require data intensive research such as all taxa biodiversity inventories, local census taking, multi-year studies of individual plants, and multi-region studies of growth and blooms. Current tools for data collection require expert knowledge for plant identification.

As part of a collaboration amongst Columbia University, University of Maryland, and the Smithsonian Institution, we have been developing new tools for speeding botanical species identification and data collection in the field [1, 2]. As a result of this collaboration, over 90,000 specimens from the National Herbarium have been digitized, new algorithms have been developed for classification of plant species based on leaf shape, and a variety of working Electronic Field Guide (EFG) prototypes have been developed and tested.

Here, we discuss five classes of user interfaces developed for this project. In our demonstration, we present two of them, created for the UMPC and the iPhone, and use them to discuss differences across all five.

User Interface Platforms

The five prototype platforms we have addressed include Tablet PC, UMPC, iPhone, head-worn augmented reality, and Microsoft Surface. Based on our ethnographic study of botanists identifying and collecting plants [6], we developed a workflow and set of functionality that have been used across prototypes. This workflow includes acquiring a physical plant specimen, identifying possible matching species, comparing with potential matches, inspecting details and characteristics of potential matches, collecting the sample and relevant contextual data, and exporting collected data.

Tablet PC

Our first prototype integrated a stylus-based Tablet PC, WiFi camera, and Bluetooth GPS receiver (Figure 1) [7]. A botanist takes a photo with the WiFi camera and the image is automatically transferred wirelessly to the Tablet PC. The Tablet PC initiates identification and displays the segmented image to provide feedback to the user about what the computer "sees." Contextual information about the collector, date, time, and GPS location (via Bluetooth GPS receiver) are automatically recorded. Possible matches are visualized using a zoomable user interface (ZUI) [3]. The ZUI provides a quick means of inspecting details of possible matches for comparison with the sample image. It also provides additional textual information about the species. A history tab shows a representation of all images collected during a given trip and can be exported in formats useful for botanical research. A browse tab provides an overview of all species in the system.

Ultra Mobile PC

We used the underlying architecture developed for the Tablet PC for our UMPC prototype (Figure 2). The prototype integrates the camera directly onto the device and reduces the physical size of the system, making it easier to carry in a holster attached to the botanist's belt. A Bluetooth WAAS-enabled GPS receiver is used for collecting geolocation information, and a live video of the leaf provides direct feedback for

Figure 3. iPhone user interface for browsing, inspection of leaf details, and matching results.

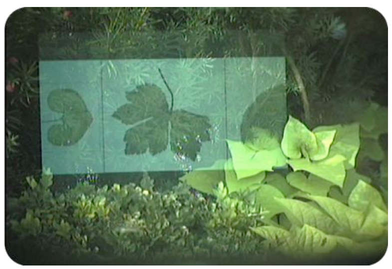

Figure 4. View through video see-through display of overlaid plant species in head-movement controlled augmented reality.

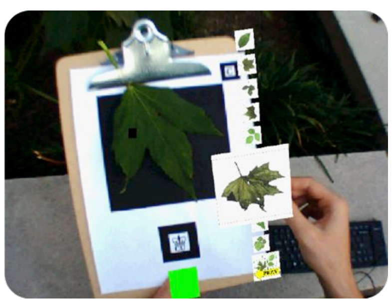

Figure 5. View through video see-through display of user selecting species for inspection in tangible augmented reality.

comparison with history or matching species. The UMPC supports both stylus and single-touch interaction. However, we found that most people used the stylus because touch detection with the UMPC was not always reliable.

iPhone

The iPhone prototype (Figure 3) borrows many of the elements from the UMPC interface, but reorients the interface from landscape to portrait and supports multi-touch interaction. The GPS receiver is integrated in the phone, so no additional devices are necessary. However, in contrast to the other prototypes, the matching algorithm currently resides on a remote server or secondary server device carried into the field, making a network necessary for full functionality.

Augmented Reality

Two different augmented reality interfaces were built on the same underlying architecture used in the Tablet PC and UMPC interface [6]. The first, a head-movement controlled augmented reality EFG (Figure 4), incorporates a head-worn display, InterSense InertiaCube 2 orientation sensor, and two buttons mounted on the device for additional control. After a leaf image is matched, results are visualized overlaid on the physical scene, floating in front of the user's view. Head movement controls magnification and species selection while buttons are used for clutching, centering, and changing semantic zoom.

The second interface, a tangible augmented reality EFG, incorporates a head-worn display, clipboard, and cardboard square. Fiducial markers are printed on the clipboard and cardboard square to obtain the position and orientation of the tangible objects. A leaf is placed on the clipboard and positioning the hand-held fiducial on the green virtual button initiates a search (Figure 5). Results are displayed along the side of the clipboard. Placing the handheld fiducial marker above any virtual leaf transforms the marker into that species. The leaf can then be inspected by moving the marker closer to the viewer, while tangible gestures such as reeling and flipping change semantic zooming levels.

Microsoft Surface

In this interface, which uses a Microsoft Surface (Figure 6), a leaf is placed on the surface of the table. Placement of the leaf is detected, the image is segmented, and results are displayed along the top of the table surface. Tapping a resultant image brings up high quality, detailed images of the leaves, fruits, seeds, and flowers of a given species. The prototype is intended for use in an exhibit at the Smithsonian and not for use in the field. The first iteration of this prototype used the same infrastructure used in the UMPC interface. However, subsequent iterations now use the server-based API.

Differences Across Platforms

The Tablet PC, UMPC, and augmented reality interfaces have been evaluated in the field and in laboratory experiments [5]. As we have developed additional interfaces for the Apple iPhone and Microsoft Surface, we have observed interested distinctions among all the interface platforms.

Portability and Integration

The weight and size of the Tablet PC motivated our shift from the Tablet PC to the UMPC. In a user study in the field, we found that while the screen real estate for displaying many matches was desirable, the botanists

Figure 6. Inspection of a leaf after classification on a Microsoft Surface.

wanted to minimize the weight of items carried in the field. In addition, we found that using a single device, rather than multiple devices, removed fear that the camera or GPS receiver might be lost. In doing this, however, we lost some interesting collaborative behavior where one person would take a photo with the camera and a second person would use the tablet.

Proximity of Real and Virtual Leaves

One interesting distinction between the augmented reality interfaces and the hand-held device interfaces is the proximity of the physical leaf to the virtual potential matches. The augmented reality interfaces overlay imagery directly on the physical scene, so the virtual leaf can appear both physically close to the real leaf and on the same visual plane. This appears to make comparison easier because it does not require switching attention between a device display and the physical world.

Manipulation Methods

One of the most important aspects of the system is the ability to inspect and compare leaves. Each platform provides methods for magnifying leaf images and inspecting them, as well as semantic zoom to explore other aspects of the species. In the tangible augmented reality user interface, the direct manipulation of the hand-held marker takes advantage of our existing spatial knowledge and required less explanation or training. For example, with the Tablet PC, UMPC, and iPhone interfaces, zooming in to take a closer look at the veins of a plant or serrated edges requires special gestures, such as pinching or double tapping with a stylus. In contrast, the tangible augmented reality system simply requires the hand-held marker be brought closer to the user, much as one would handle a real physical leaf. Leaves lend themselves to tangible augmented reality using a handheld marker because they are already flat.

Location of Interface Elements

In contrast to the Tablet PC, UMPC, and iPhone systems, in the augmented reality and Surface systems, user interface elements are displayed around and associated with physical leaves. In addition, the information appears to come directly from the leaf, rather than from a separate device or system. This appears to more closely create a cognitive association between the data and the physical leaf.

Handheld Orientation

In moving from the Tablet PC to the UMPC and then to the iPhone, we found that users hold the devices in very different ways. The iPhone is held with a single hand in portrait orientation, while the UMPC was always held with two hands in landscape orientation. This meant that user interfaces for the UMPC were placed in close proximity to the location where thumbs would often be positioned, while the iPhone provides a greater range of user-interface–element placement.

Data Management

The iPhone version is the first one to require a network to function properly. While a base-station can be carried into the field, we currently rely on a remote server at Columbia University. This requires more sophisticated data management, both for individual species images and for access to matching results [4].

Image Capture

With the exception of the Microsoft Surface prototype, all the systems use a conventional color still or video camera to capture the image of the leaf laid out against a light, solid-colored background, illuminated from above for segmentation and matching. In contrast, the image of the leaf on the Surface is illuminated and captured from below by IR light sources and cameras in the Surface. While the Surface makes it easier to segment this image, details of the leaf are lost and leaves that curl up may lose details at the edges, since items that are not very close to the screen reflect relatively little light.

Conclusions

We have presented a suite of user interfaces to botanical species recognition and discussed some of the distinctions and similarities across the different platforms.

In our demonstration, we will present the UMPC and iPhone prototypes and use them to frame a discussion of the user interface issues found through use and evaluation, and which are noted here.

Acknowledgements

We thank Peter Belhumeur, David Jacobs, and John Kress for collaboration on this project; Ida Lopez, Norm Bourg, Rusty Russell, and Jamie Whiteacre for their support at the Smithsonian; Haibin Ling, Sameer Sheorey, Jason Kopylec, Dominic Marino, Joseph Lin, Neeraj Kumar, and Jacky Jacob for their contributions to the development of these user interface platforms. This work was funded in part by NSF Grant IIS-03-25867 and a generous gift from Microsoft Research.

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