

LeafView: A User Interface for Automated Botanical Species Identification and Data Collection

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ABSTRACT

LeafView is a Tablet-PC-based user interface for automated identification of botanical species in the field, developed for the Columbia, University of Maryland and Smithsonian Electronic Field Guide Project. Leaf images are captured with a digital camera and wirelessly transferred to the tablet. A computer vision component developed by our colleagues finds the best set of matching species, and we present the results in a zoomable user interface. Samples are matched with existing species or marked unknown for further study. A history of collected samples along with collection context can be browsed for further study and comparison. The system has been field tested by Smithsonian botanists on Plummers Island, Maryland.

ACM Classification: H5.2 [Information interfaces and presentation] User Interfaces—*Graphical user interfaces*.

General terms: Design, Human Factors

Keywords: Electronic field guide, mobile computing, tablet, computer vision, botanical species identification

INTRODUCTION

As biodiversity and ecological research become more crucial, better tools for botanists must be developed. Of particular importance is the need to identify specimens in the field and associate them with an existing species or potential new species. In this process, data must also be collected for review and comparison. Columbia University, the University of Maryland, and the Smithsonian Institution are working together to develop electronic field guides that support vision-based automated species identification [1, 2]. The goal of this overarching project is to radically change current practice, in which botanists use paper field guides and their own personal knowledge to identify species. To confirm the identification, they must then compare the sample with a canonical specimen of the species, called a *voucher*. Vouchers are stored in academic or institutional herbaria and require travel to the herbaria or shipment of the vouchers to the remote locale for verification. For each identification task, this process is time consuming and requires the movement of unique and fragile voucher specimens, which may be lost or destroyed during transfer. Thus, botanical research is



Figure 1: Electronic Field Guide prototype, showing the sorted results from automated species identification. Each leaf represents a virtual voucher.

constrained by the identification task in the field and availability and access to botanical data.

In previous work [6], we performed an ethnographic study as part of the design of several prototype augmented reality user interfaces to species identification. We introduced the term *virtual voucher* to describe a digital representation of the botanical reference specimen in conjunction with its contextual and characteristic data. This data includes additional imagery of the whole plant and root systems, location and date of acquisition, name of the collector and of the identifier, regional information, articles about the specimen, and links to related specimens. The term more generally describes a holistic virtual representation of an object in the physical world. Here we present a new Tablet-PC-based prototype, LeafView (Figure 1), which is being field-tested by our botanist colleagues at the Smithsonian.

Prior research has used mobile devices for recording data in field work, such as the PDA-based FieldNote [5] system. More recently, ButterflyNet [7] has relied on a paper notebook with an Anoto digital pen, in conjunction with a small computer and camera to capture time-stamped and barcoded images of specimens, thereby associating field notes with collected specimens. In contrast, our contribution is the development of a mobile user interface to an automated species identification system that combines collection and identification.

COLLECTION AND IDENTIFICATION

The LeafView user is presented with tabs for browsing, samples, search results, history, and help. The collection process starts by taking a photo of the leaf. The image is immediately transferred through an IEEE 802.11g or Bluetooth (we support both) wireless network to the tablet system. On arrival, the image is displayed in the samples tab and the image is segmented by the vision algorithms [4]. A thumbnail of the sample is also placed in the history tab and all contextual data about the sample, such as GPS location, collector, and time/date, are stored in a database. When segmentation completes (ca. 6–11 seconds from shutter release), a search is automatically initiated in the background. The search component, developed by our colleagues, uses their inner distance shape context (IDSC) algorithm [4] to match plant species, and we provide hooks for integrating other algorithms. Once the search is complete (ca. 35–40 seconds from shutter release), the ranked results are displayed in the results tab on a zoomable canvas. Human interaction is required because the vision algorithms are not perfect. The user can pan and zoom to inspect individual virtual vouchers and compare them with the plant sample. Once the identification has been verified by the botanist, a button press associates the identified species with the sample. A zoomable history of samples can be browsed to recall prior samples and search results.

INTERACTING WITH VISION ALGORITHMS

Vision algorithms are often treated as black boxes that provide no feedback on success or failure modes. To address this, we display the segmented image alongside the sample image as IDSC is executed (Figure 2). This provides immediate feedback regarding the quality of the segmentation. Botanists can retake the image with knowledge about the segmentation quality if search results are poor.

IMPLEMENTATION

The software was developed using C#, MatLab, and Piccolo [3] for the zoomable user interface. The hardware consists of Motion Computing LE1600 and Lenovo ThinkPad X41 Tablet PCs, a Delorme Earthmate GPS, a Nikon Coolpix P1 Wi-Fi camera, and a Sony Ericsson T616 Bluetooth camera phone.

USE IN THE FIELD

To gain insight into the use of the system in the field, our botanist collaborators have been using the LeafView prototype on Plummers Island, a small island in the Potomac that has been extensively studied by naturalists since 1908. Samples were acquired in two different ways. In the first approach, an image was taken and the system was immediately checked to see the results of the search. The retrieved virtual vouchers were inspected and a match was chosen. The botanist then went on to the next leaf for collection. In the second approach, the botanist took a series of pictures and then used LeafView to review the images and create matches, in some cases also comparing multiple samples to see if they were the same species. In the first approach, the prototype successfully fit into the botanists' preexisting collection patterns and matched a large variety of plant specimens.



Figure 2: Original and segmented images.

The second approach was not predicted by the authors or the botanists and revealed new opportunities for developing the UI, which we intend to explore.

CONCLUSIONS AND FUTURE WORK

Our colleagues have successfully used LeafView in the field and we are currently improving the design with them. As a qualitative litmus test, we received numerous protests when we took the prototype back to make adjustments to the hardware and software. We will be taking the prototype to an ecological preserve in Panama this year for further field tests and to explore integration with ecological data.

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