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mAPPING Roadkill to Improve Driver and Wildlife Safety on Highways

A Research Report from the University of California Institute of Transportation Studies

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16. Abstract This application framework will provide Caltrans staff and partners the ability to easily collect information on roadside features and document their findings in a web-based database which can be shared within Caltrans, as well as externally. The "one-click" application allows for users to simply point at a roadside feature, snap a photo, and this information will automatically be sent to the image server for processing. Additional annotation can be added (such as an animal species), which will provide the necessary verification steps for a complete and permanent record. These data are a critical first step to mitigating impacts to drivers and animals from collisions.			
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The University of California Institute of Transportation Studies (ITS) is a network of faculty, research and administrative staff, and students dedicated to advancing the state of the art in transportation engineering, planning, and policy for the people of California. Established by the Legislature in 1947, ITS has branches at UC Berkeley, UC Davis, UC Irvine, and UCLA.

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mAPPing Roadkill to Improve Driver and Wildlife Safety on Highways

UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

June 2017

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TABLE OF CONTENTS

Executive Summary 1

Introduction 2

Approach and Findings 3

 Application Architecture3

 Application Overview4

 Application Details: Phone Side4

 Application Details: Server Side6

 Current Status6

Conclusion 6

References 7

Executive Summary

Wildlife-vehicle collisions (WVC) pose a risk to drivers and annually costs US society billions of dollars in property damage, emergency response, maintenance and mitigation activity, and lost economic activity. Reducing occurrence of WVC requires identifying places where these collisions are more common and mitigation activity could improve safety while driving and protecting the environment. Both objectives are part of developing more sustainable transportation. One of the greatest hurdles in reducing WVC is data collection about the extent and nature of the incidents. We developed a set of tools to help with this problem, including the “One click” app which will help Caltrans and others to collect WVC data.

We developed the app to be cross-platform and useable in further development for Caltrans Maintenance staff and potentially others within and outside Caltrans collecting information about roadsides and highways. The Maintenance Division expressed interest in an app that their staff could use to initially report carcasses during cleanup and possibly to be used to report other environmental and roadside conditions. This contemporary solution would be complemented by similarly contemporary web-based informatics.

Introduction

Monitoring environmental conditions and investigating causes of change allows society to make decisions about conservation (Wilson, 1999; Devictor et al., 2010; Bang and Faeth, 2011; Corona et al., 2011) and improve management of human-nature conflict. Involving society, including agency line staff directly in scientific investigation can transform science from an exclusive process, remote from peoples' day-to-day experience, to one that includes millions of new environmental data collectors. Projects involving lay-people as scientific data collectors have grown considerably in recent years (Silvertown, 2009; Conrad and Hilchey, 2010; Roy et al., 2012), providing data collection at large geographic scales (Devictor et al., 2010), that are often of high-quality (e.g., Ratnieks et al., 2016), have been found to be useful for species-distribution modeling (e.g., Mair et al., 2016), and help connect people to nature and conservation problems (Cooper et al., 2007; Devictor et al., 2010). Sub-national and national governments including transportation organizations (e.g., Harris et al., 2016), are increasingly recognizing the importance of public-collected information (e.g., Bowser and Shanley, 2013 and the Federal Crowdsourcing and Citizen Science Toolkit, <https://crowdsourcing-toolkit.sites.usa.gov/>).

Volunteer and agency staff scientists may play an important role in understanding the changing distributions of biodiversity (Mair et al., 2016). Their role as sensors can multiply the geographic extent of observations many-fold compared to academic or governmental scientific investigations, while providing data of comparable quality (Ryder et al., 2010; Haklay 2013). While operating across large geographies (US states), volunteers can maintain observations across broad taxonomies and large spatial extents. In addition, they form both an immediate constituency for science and conservation as well as a face on science that other members of the public may more easily relate to (see Ceccaroni et al., 2016). However, although this position in conservation may be typical (Ceccaroni et al., 2016), the authors are not aware of a demonstration of the effectiveness of volunteer science in changing how natural systems are managed. In particular, transportation organizations have not embraced volunteer-collected data, possibly because of a lack of published evidence of their potential quality.

Informatics is a discipline that provides tools useful to collect, manage, and use diverse types of data to support research and management. The field of web-based environmental informatics has recently evolved in order to assist with large scale environmental analyses, data management, data contributions from disparate sources, and decision-support (Reichman et al, 2011). Public-oriented informatics is an emerging area of practice that could support ecological research, provided broadly-accepted rules are used for developing and sharing controlled vocabularies, data storage models, and metadata. At the same time, emerging social-network and data-mining methods are greatly increasing our abilities to classify data, estimate trustworthiness, statistically model geographic distribution from point observations, and to provide data directly to rapid response and long-range policy-making. When combined with

successful recruitment of staff and volunteers, informatics is critical in providing a transparent, extensive, scalable, and accurate observation system to capture environmental processes.

Caltrans leadership expressed interest in working with the Road Ecology Center on improving their field monitoring of environmental conditions and activities, especially related pick-up of roadkilled animals. Currently, Caltrans maintenance staff record their activities on paper in the field and transcribes that information to a digital system when they get back to the maintenance stations and regional offices. This system not only makes it challenging for individual staff to keep track of activities, it also reduces the chance that valuable information (like the collection of location and wildlife species) will be retained and transcribed correctly. In our review of field-collected data, quite often activities, including carcass cleanup, is recorded and associated for very long stretches of road (e.g., 20 miles of an interstate). This makes identifying locations of hotspots very challenging since the exact position is often too coarse. Maintenance staff are often the first line of responders to non-emergency roadside incidents, which include illegal dumping of unsightly or dangerous waste, cleanup after collisions, material flying or being thrown from vehicles, vegetation management (mowing, weed-control, planting), and cleaning up wildlife carcasses. The staff are required to report, record, and track this work for administrative and funding reasons. The upside is that maintenance staff are potential sensors for important events in the roadside, including weed invasion, fire hazards, and wildlife occurrences including mortality from WVC. To facilitate this process, we developed an app and server side combined application to make recording carcasses and other roadside events very easy for staff and volunteers

Approach and Findings

The smartphone application we have developed with PTA fund support is the first step to putting a set of tools in the hands of the ~5,000 Caltrans Maintenance Division staff that are in the field every day cleaning up trash, collecting wildlife carcasses, and managing the roadsides of our >12,000 miles of state highways. The app will support the eventual development of an activity reporting system, including the collection of animal carcasses, which includes the app and web-services. This will help both with finding hotspots of wildlife carcasses resulting from collisions and with carrying out other cleanup and maintenance activities (e.g., weed-management, trash cleanup) critical to improving state highway rights of way.

Application Architecture

Below is a simplified model of the system architecture (Figure 1). The “One click” app allows the user to snap a picture using the tablet/phone’s camera, which is then sent automatically to an image management server. The device’s location (where the photo was captured) and the date/time are stored with the picture, and sent to a server for processing and additional attribution. On the image processing server, users can “tag” the incoming photos with other important information, such as the animal’s species, to comprise the core data for reducing

WVC. Tools such as the California Roadkill Observation System (CROS) and Caltrans Maintenance Database (not currently developed) can then import these images into their system for further utilization in their respective environments. Sharing between the Image Server, CROS, and Caltrans Maintenance Division databases will occur, utilizing both “push” (direct import) and “pull” (content feed) methods.

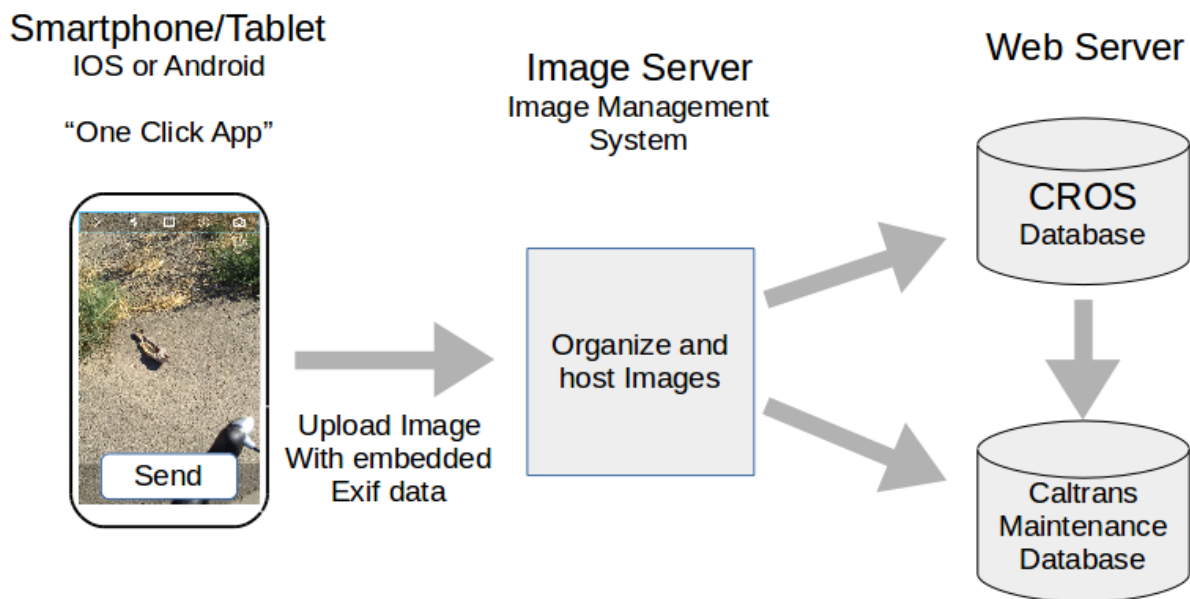


Figure 1. Overall workflow from the phone-based app to the server-side database(s).

Application Overview

The “one click” app supports Apple iOS and Android based smartphones and tablets, making it cross platform. We use the photo’s Exif region to store these data, which is a standard feature of all JPG images. Our objective was to make the app as easy to use as possible, so all the person needs to do is snap the photo. The app will handle the transfer of the photo to the image server where other tasks are carried out, such as tagging the images with animal species and providing them to CROS and the Caltrans Maintenance database. Image data with accurate embedded location and date/time information are verifiable and hence, trustworthy.

Security is a major concern for our team. The tools developed will have several verification steps built into the workflow to prevent unwanted photos or unregistered users from posting images to the image server, or upload images with inconsistent embedded content.

Application Details: Phone Side

We chose **Cordova** as a framework because it uses programming languages used for web development, on mobile devices. One can access the web on any device regardless of platform, allowing communication with any device's underlying hardware. In iZap, we take advantage of

Cordova's capabilities by using the "camera" and "geolocation" plugins which come with functions specifically geared toward those components. For example, the "geolocation" plugin allows us to control HOW we want to measure a user's location: should we use network-based methods? or GPS (satellite) positioning? If we know the user is surrounded by wifi, obviously it means they're indoors a lot, and GPS might not be as accurate because it would have to penetrate through buildings. In our case, we know satellite positioning would probably be more accurate since there's a less likely chance of field staff having access to Wifi. This is also how the system is able to be cross-platform.

Ionic is the package we chose to take care of the User Interface/User Experience. It provides pre-stylized application templates, buttons, and other components. For example, we decided to include a "side-menu" so that the user can navigate to the Login page without leaving the Camera page, and this was a pre-made template on Ionic. On the "Select Country Code" page is an example of how Ionic makes a basic, un-styled page look "modern" by default. Also, it optimizes the design based on which platform the app is being used on, so that it renders beautifully on any device. Another advantage of Ionic is that it has a marketplace, where people can buy and sell other templates. We purchased a \$10 phone verification template for the app front-end; we had to implement the functionality ourselves. In short: Ionic is the glue making the application act like a "native" phone application.

The user sign-up is intended to be a first time only step. After the user has done this, they will not have to do it the next times they use iZap. First, the user must select a valid country code from a list. Then they need to enter their phone number. We have an automated process using Twilio which automatically sends a verification code that we have randomly generated, as a text message, back to the user. The user enters that code they were texted from within our app, and can only proceed to the camera page if the user's input matches the verification code. This is why we require their username to be their phone number; if they enter a fake number, they obviously won't get the text message, or access to the camera.

Once the user is authenticated, they are sent back to the camera screen. This is our "default state", meaning anytime the user opens the app now, it is automatically on the camera screen, for convenience' sake. We have included current time, latitude and longitude information on this page as well. Upon first use, there will be a pop-up asking for permission to access their GPS. If the user clicks yes, these values are filled in. Once this step has been completed, the camera opens within the app. The user can take the photo of an event (such as an animal carcass on the road), and the application asks for permission to use the User's Library (this is done using the Cordova file transfer plugin) which allows us to automatically save the photo locally whenever the user takes a photo. Once the User takes a picture, a button appears that says "Use Photo"? If the user clicks "Yes", the photo will be uploaded to the "intermediate" server, and the User is taken back to the camera screen.

Application Details: Server Side

We also used Cordova to transfer the image file to an intermediate server at UC Davis. We used the “flask” framework to prototype a server to be able to receive photos. After developing this approach, we then found another framework (“node”) that we believe would be better suited for that purpose and we are trying it out now. We then used an external javascript library for verifying that phone numbers entered by users (see above) are the correct length and have a valid area code. There are a few quirks about the current way that we are using the Twilio API that need to be ironed out, namely we currently have a dedicated node server running to handle the “webhooks” for the API. In the future we will work to integrate this with the node server that will be used to store image files (Figure 2) before they are digested by the Drupal content management system into a more usable form.

Current Status

The app is currently going into beta testing on the app store. It will be called iZap and will be tested by agency staff and others within and outside California. After beta testing, feedback from clients and performance of the app and server-side applications will be used to confirm performance across phone platforms, user types, geographies. We expect formal release of the tested and updated app by August.

Conclusion

This application framework will provide the ability for Caltrans staff and partners to easily collect information on roadside features and document their findings in a web-based database which can be shared within Caltrans, as well as externally. The “one-click” applications allows for users to simply point at a roadside feature, snap a photo, and this information will automatically be sent to the image server for processing. Additional annotation can be added (such as an animal species), which will provide the necessary verification steps for a complete and permanent record. These data are a critical first step to mitigating impacts to drivers and animals from collisions.

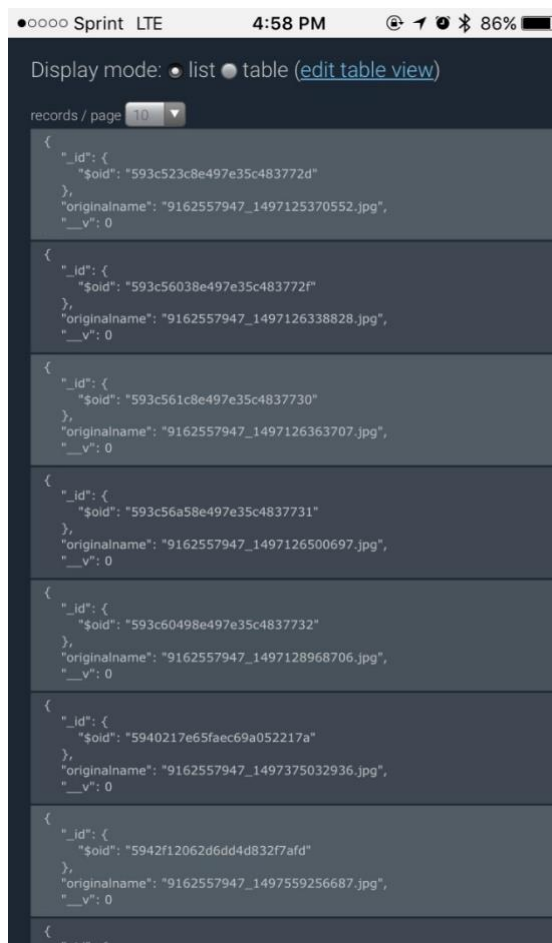


Figure 2. The image file information stored in the server-side database.

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