SakuraSensor: A System for Realtime Cherry-Lined Roads Detection by In-Vehicle Smartphones

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Abstract
SakuraSensor is a participatory sensing system for collecting short videos of cherry-lined roads by in-vehicle smartphones to provide scenery-based route recommendation services for comfortable driving. To detect good cherry-lined roads and record their videos automatically during driving, image analysis techniques are performed on user's smartphone, and the degree of flowering cherries (*cherry intensity*) along the roads are calculated in realtime. In this demonstration, we show how flowering cherries are detected from the videos along with the actual values of cherry intensity, and show a map-based user interface for viewing short videos recorded on the cherry-lined roads.

Author Keywords
Participatory Sensing, Flowering Cherries Detection, Image Analysis

ACM Classification Keywords
I.4.9 [Artificial Intelligence]: Applications

Introduction
To facilitate comfortable and efficient driving, car navigation and routes recommendation services have been used to support decision-making of drivers. In recent years, sensing techniques using car-mounted smartphones have been intensively explored, creating an opportunity to develop new

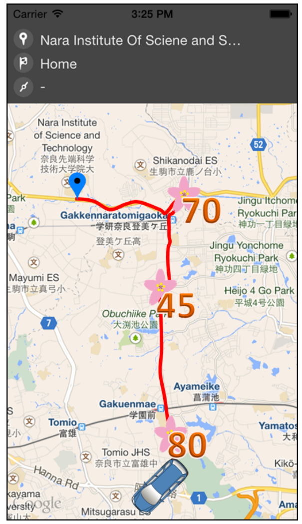

Figure 1: A scenery-based route recommendation service

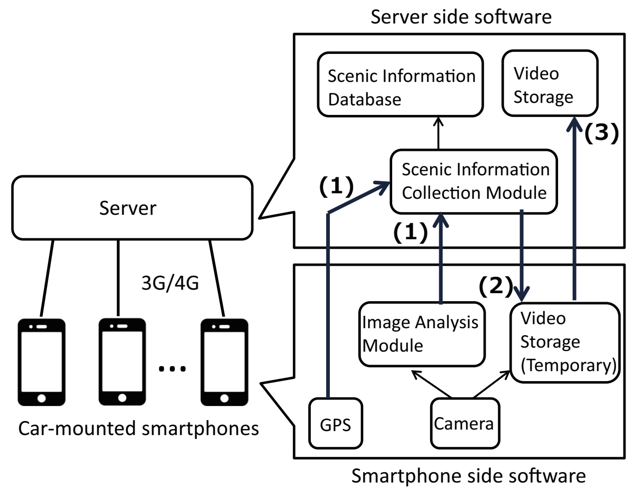

Figure 2: System architecture

types of services, such as sensing of parking spot occupancy [1], prediction of traffic signal schedule [2], and detection of dangerous driving conditions and behavior [3]. Among them, we focus on scenic routes recommendation services, which have begun to be provided such as scenicbyways.info[1] in recent years. In the existing services for scenic routes recommendation, however, the number of pre-determined spots is relatively small and information update frequency on the spots tends to be low. Moreover, it is difficult to intuitively grasp what kind of scenery will be able to view in advance from out-of-date still images or texts. To address these problems, we developed *SakuraSensor* [4], a participatory sensing system which detects cherry-lined routes through image analysis of videos recorded by car-mounted smartphones and shares the degree of flowering cherries (called *cherry intensity*) along roads as well as short videos with high cherry intensity among its users. Based on the collected information, routes recommendation services with up-to-date information can be provided, where the users can find scenic routes and preview short videos on the retrieved routes.

In this demonstration, we show how flowering cherries are detected from videos in realtime and how the cherry intensity and short videos are shared among users with a routes recommendation service (Figure 1) by using several iOS devices.

System Architecture

The routes with flowering cherries are identified by associating the cherry intensity with location information. One approach for this is to perform image analysis techniques that calculate cherry intensity on the server. However, it would

[1] http://scenicbyways.info

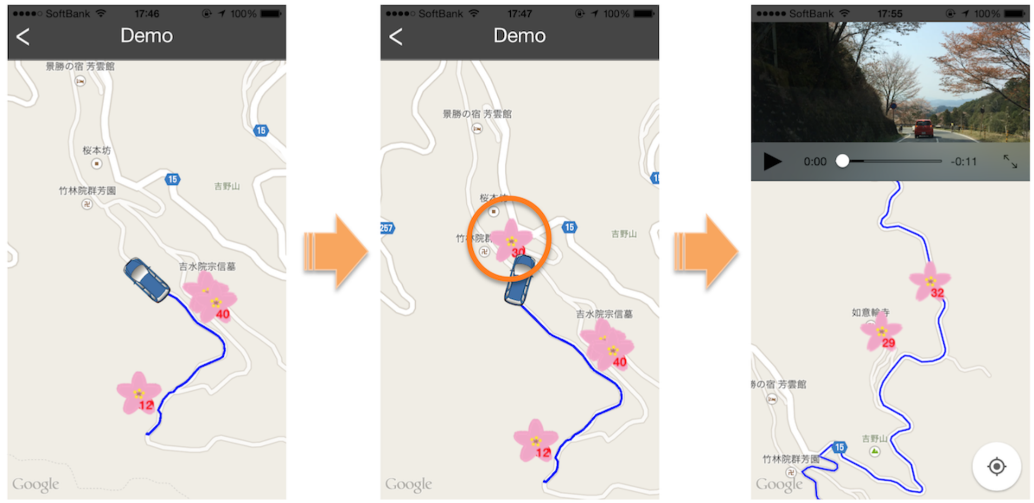

Figure 3: Sharing cherry intensity & short videos on the map

not be possible to continuously transfer recorded videos from a smartphone to the server due to the limitation on the communication bandwidth of 3G/4G network or monthly available communication amount limitation posed to users. To cope with this limitation, in the proposed system, instead of uploading the whole video immediately after recording it, the smartphone side software performs image analysis techniques to calculate cherry intensity, extracts *short videos* (e.g., 10 seconds) with high cherry intensity from recorded videos, and uploads them to the server based on the requests by the server.

Figure 2 shows the overall architecture of the system, which consists of the application running on a smartphone and the software running on the server. At the smartphone side, while a car is traveling, the smartphone continuously records GPS logs and videos captured by its camera. Cherry intensity is continuously calculated and uploaded to the server in realtime (arrow (1) in Figure 2). Then, PoIs (*Point of Interests*), which have especially high values of cherry intensity, are detected on the server, and the server sends request for the short videos to the smartphones (arrow (2) in Figure 2). Finally, the videos recorded on the PoIs are received and stored by the server (arrow (3) in Figure 2). To efficiently collect short videos from multiple cars, a multi-stage sensing method (called k-*stage sensing*) is employed, which controls the sensing frequency of each car based on the density of PoIs that are already found by other cars. Please refer to [4] for details about k-stage sensing.

Detection of Flowering Cherry

To accurately detect flowering cherries, SakuraSensor employs histogram-based color analysis and region-based

Figure 4: Realtime cherry intensity calculation in client-side software. Cherry intensity is represented by five stars on the toolbar located at the bottom of the screen.

fractal dimension analysis techniques. In the histogram-based color analysis, multiple frames are sampled from each video recorded by a smartphone, and for each pixel of each frame, the frequency that the pixel belongs to flowering cherries is calculated. Then, the cherry intensity is calculated for each frame as the mean value of the frequency of all pixels in the frame. In addition, fractal dimension analysis is performed before calculating the cherry intensity to filter out objects that contain the similar colors in flowering cherries (e.g., signboards). More details of the image analysis methods used in SakuraSensor can be found in [4].

About 5000 short videos (each is 1 second long), which are extracted from the recorded videos, are classified into multiple classes depending on the amount of flowering cherries contained in each video using SakuraSensor, and compared the classification result to the manual classification by human. Through experiments, we confirmed that SakuraSensor can determine whether flowering cherries are contained in a short video or not with a precision of about 73 % and a recall of about 83 % [4].

Demo

We have implemented the user side software for iOS (version 8.1.3) devices and the server side software for PC with Linux. The information collected consists of GPS logs, cherry intensity, and short videos at locations with high cherry intensity. SakuraSensor takes an image (i.e., a frame sampled from a video stream) as an input and outputs its cherry intensity, which quantifies the amount of flowering cherries in the image. As shown in Figure 4, the client-side software records videos and calculates cherry intensity in realtime. Calculated cherry intensity is shown on the smartphone screen as cherry indicator represented by five stars.

We show the demonstration where several iOS devices running the client-side software calculates cherry intensity and shows it as cherry indicator in realtime from the videos recorded in advance. We also demonstrate that the cherry intensity along roads and the short videos extracted for high cherry intensity locations are shared in realtime among users as shown in Figure 3, where videos with high cherry intensity are played back by tapping a cherry icon on the map.

Acknowledgments

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