An Image Change Detection Application for Field Server

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Abstract

Field Server is a Web server that has a weather station and a camera. It is installed in many fields all over the world, and stores meteorological data and images into the server periodically. The stored images are used to observe the growth of plants and to detect the changes in a field by displaying continuously as animation on a Web browser. Since a standard Field Server camera takes an image every 2 minutes, a total of 720 images are stored for each target area every day. It was becoming difficult to utilize the enormous number of stored images with the simple image viewer application.

Then, it was decided to execute image change detection using image processing. Since there is no big change from one periodic image to the next, it is not difficult to detect changes, such as the appearance of a worker or an invader. However, since the target image is an intermittent image, the shaking of branches, the movement of shadows and the sudden ambient illuminant change will be extracted as changes. This problem was solved by using two-dimensional density histogram and local image processing developed by AIST.

The program incorporating this algorithm is executed in a server and records the change information including the time, the change area and level in an XML file. As a user interface to allow users to view changes between images, the thumbnail type and the Timeline type are provided.

This system is used to appeal the safety of agricultural products by extracting the images of agricultural work and showing them to a consumer, and to monitor the theft of agricultural products and illegal disposal of garbage.

Keywords: image change detection, Field Server, XML

Introduction

Field Server is a distributed sensing device to use in fields which consists of a Web server, multi-sensors, Web camera and wireless LAN module (Fig. 1 left). It has been installed in many fields all over the world, and stores meteorological data and images into the server periodically. Since a standard Field Server takes an image every 2 minutes, a total of 720 images for each target area are stored every day. The stored images are used to observe the growth of plants and to detect the changes in a field by displaying as thumbnail images or as animation with a Web application.

Since changes do not occur fundamentally between the images taken by a Field Server in the field, there was a request by users to see only the images in which change took place out of a vast quantity of images. It was not realistic to perform this task manually every day, so the
image change detection system was developed to detect and show only images with change. The structure of the image change detection system is shown in Fig. 1.

Fig. 1 The structure of the image change detection system.

**Image Change Detection Server**

Image change detection is performed in a server in the following steps (Fig. 1 upper right).

1. Download images from the image server to the image change detection server.
2. Execute the image change detection program, and calculate the value of change between each image and the one that preceded it.
3. Transform the change information into XML format and output it to a file.

Since the number of the images for change detection is huge, the program is performed by batch processing, resulting in new stored images.

Since a Field Server is installed outdoors, small movements that should be disregarded, such as density change by daylight, the shaking of a tree by wind, and clouds flowing past, are captured in the images. These conditions had to be considered when selecting an image change detection program. With that prerequisite, the image change detection process using joint intensity histogram and local image processing developed by the National Institute of Advanced Industrial Science and Technology (AIST) was adopted. The former method detects changes caused by the shaking of branches and the movement of shadows using their two-dimensional (2D) histogram of combinatorial intensity. The latter method detects changes caused by the sudden ambient illuminant change. The target of the method is to detect only significant changes such as appearance / disappearance of objects from a dominant background of outside scenes suffering daylight variation. The algorithm is comprised of the following steps:
1. Calculate the joint histogram, which is a two-dimensional histogram of combinatorial intensity levels, \((I_1(x), I_2(x))\), where \(I_k\) represents intensity levels \((0 – 255)\) of each image.

2. Select clusters expected to correspond to the background by checking the characteristics of ridges of clusters on the joint histogram.

3. Determine the combinations of \((I_1, I_2)\) covered by the clusters as insignificant changes, and determine the rest of the combinations as significant changes.

4. Build a table \(\text{Sig}(I_1, I_2)\) which classifies combinations of \((I_1, I_2)\) into significant / insignificant changes.

5. Extract pixels with significant changes from the images by comparing \((I_1(x), I_2(x))\) with the table.

6. Remove small size regions from the candidates for significant changes.

7. Determine the change area of the image by checking gradient correlation between the images for the candidate regions.

The result of image change detection is output to an XML format file, as shown in Fig. 2. It contains the event element corresponding to each image. The time with the image was taken (start), the URL (image), the change value (change) and the change area coordinates of an image (area) are recorded as attributes of event element.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<data>
  ...
  <event start="2007/04/01 07:50:00 +0900" image="http://fsds.dc.affrc.go.jp/data4/Ichikawa10(cam)/200704/20070401/200704010750.jpg" change="12932" area="(69,207)-(180,302)" />
  ...
</data>
```

Fig. 2 The XML data for image change information.

**Web Application to Show Changes between Images**

A user can see the extracted changes between images with a Web application, which shows images as thumbnail (Fig. 3) and as Timeline (Fig. 4), which is a DHTML-based time-axis display widget. The thumbnail is suitable for displaying many images at the same time. Since the movement of the time axis of Timeline is performed with mouse drag, it is suitable for seeing images, grasping sensuously the time when change occurred. Both of the presentation methods acquire the XML file that the server recorded and create the Web page using Ajax. A user can select the Field Server, date, presentation method, whether squares display changed areas or not, and the threshold for when an image is considered to be an image change.
Results

The pairs of image detected by the image change detection system are shown in Fig. 5. The right-hand side of a pair of image is the detected image, and left-hand side is the image taken just before that. People and a car are detected regardless of conditions, such as the background, the size of appearance objects and the weather. Although only the examples which detected the appearance of objects as change is shown in Fig. 5, subsequent disappearance of objects is also detected as changes. Since multiple square showing a change area are shown on one change object, it is difficult for detecting the number of an object which caused change.

The pairs of image incorrect-detected are shown in Fig. 6. The strong density change by daylight and movement of clouds are incorrect-detected as change.
Discussion

A system that detects changes from a vast quantity of images taken by Field Server has been developed. In this system, a joint intensity histogram method was adopted as the image change detection process. The characteristic of this program is that it detects the significant changes resulting from invasion by people and cars, but it does not detect the insignificant changes of density by daylight and the shaking of trees by wind. This method suits the purpose of the image change detection system. However, since clouds flowing by were detected incorrectly in many cases, improvement of the system to exclude the area of sky from the objects to be detected is required.
The Web application using thumbnails and Timeline was developed as a user interface to show changes between images to users. Since a square is shown on the change area of an image, the content of change can be known by comparing that area with the same area on the previous image.

This system is used to appeal the safety of agricultural products by extracting images of agricultural work and show them to a consumer, and to monitor the theft of agricultural products and illegal disposal of garbage.

Since the XML file format is defined for recording change information, it is possible to add a new image change detection program and a new user interface, and to choose a program and an interface by users.

To raise the accuracy of the image change detection system, improvements are needed in setting up the threshold for an image change and for optimizing the program parameters based on the installation location of a Field Server. Moreover, since only batch execution processing can perform image change detection now, providing an on-demand execution service in which a user specifies an object image and a set of parameter should be considered.

References


