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WIPAD: An Automatic Monitoring System with Wireless Network based on Image Processing for Harvest Disease

Ming-Ming Xiao

Information College, Zhongkai University of Agriculture and Engineering, Guangzhou 510225, China

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Abstract: In this system, an intelligent monitoring system for crop is implemented, it comprises various function modules, the kernel one is the automatic identification module of the plant diseases and pests. The feature preprocessing is first carried out to generate the various feature vectors, and then a SVM classifier is trained from these vectors. The experimental results firmly demonstrate the discriminating function of the SVM classifier.

Keywords: Image identification, wireless network, crop diseases monitoring, SVM

1. Introduction

In current system, an intelligent monitor system for crop is implemented, it gathers various functions, such as remote monitoring and storage for agricultural information, user online web quiz, web online specialist answering, user quiz by mobile and email, automatic online crop disease diagnosing and short message reply, etc.

In summary, the main function of this system can be gathered as follows:

1) Crop information online monitoring. As crops are distributed on wide farm, it is not realistic to inspect the crop information with wired way. In current system, the technology of wireless sensor network is applied, namely, the wireless sensor nodes are widely distributed in the planting scene, the inspected data are transferred to the information station of country by wireless transmission and transfer of node, and the data are transferred to remote server.

2) The inspected data can be visited, managed and maintained from web explorer. User not only browses the website to refer to the plant diseases and insect pests, but also login the website to consult the specialist, or they can quiz by e-mail remotely. The specialist might visit the website to browse the detected data of crop, or to answer the question of user.

3) To quiz using mobile telephone and gain a reply. User can login in the mobile internet to initiate a quiz via a mobile telephone. When the quiz information is sent to the corresponding telephone number, the DTU connecting with database server can received the short message and store into database. When specialist login the website and make a reply, the system would automatically sent the reply of the specialist to the corresponding mobile of user by the DTU.

4) Automatic plant diseases image identification. If the quiz concerns image, the system can implement the automatic image identification, namely, it can determined the type of the plant disease and pets, and then it would make a reply automatically. If it is failed to the identification, the task is delivered to specialist to make a manual identification.

2. System framework

Figure 1 presents an overview of system framework. The current system comprises various module, such as the crop information online inspecting, short message and mail transferring module, and the crop diseases and pests identification module, etc.

1) The online monitoring of crop information

The online inspection process is implemented by the wireless inspecting network and information station of country. The inspecting network is established based on wireless sensor network, such as the collecting sub-system of temperature and humidity, the wireless module is constructed

* Corresponding author: e-mail:xmingm@mail2.sysu.edu.cn

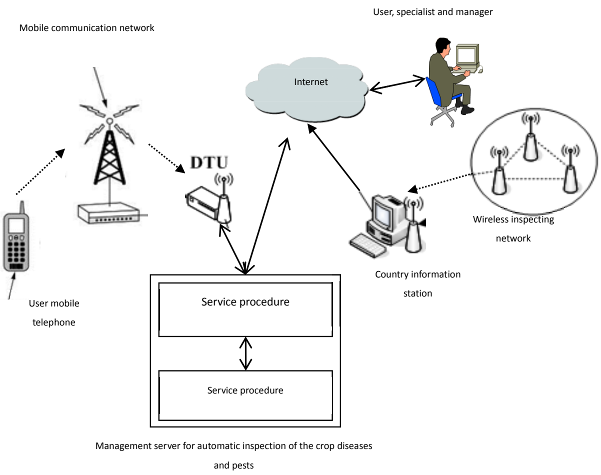


Figure 1 System framework overview.

using CC1100 to establish the node collecting net, the data of sub-node is gathered to aggregating node such that to transfer the data of temperature and humidity to PC system.

2) Short message transmission module

When user send the quiz to corresponding accouter via short message or e-mail, the procedure would automatically download the new message, e-mail and associated attach to store them into database; the specialist and user would visit the website to inquire the related information; after the reply is done by the specialist, the procedure would automatically sent this reply to the consultant.

3) Identification of the plant diseases and pests based on computer vision

Computer vision provides an new research thinking and technology means along with rapid development of computer technology, and deep understanding to the object feature, such as shape, size, color and texture. During the identification, aimed at some feature in plant diseases zone to carrying out analysis, it can effectively determine the position of plant diseases zone. The goal of current module is to make an image segmentation for the plant diseases zone and to extract the parameter of the color feature such that to implement the image feature extraction of the plant diseases, and train the classifier to realize the identification of crop diseases and pests.

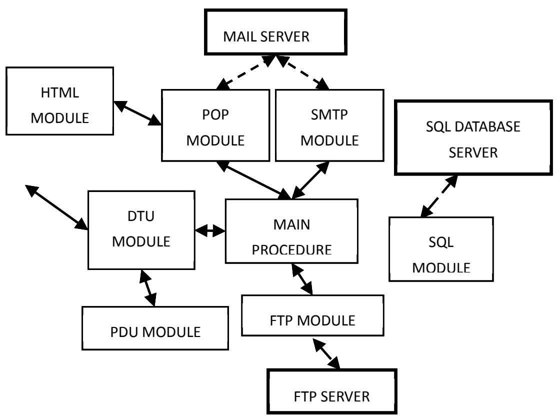


Figure 2 Framework of the short message transmission module.

3. Image identification of the plant disease and pests

This section researches the image extraction for the zone of the plant disease and pests.

A. Preprocessing feature

Color feature extraction. Color component is one of the features that can express the feature in the zone of plant diseases and pests. The highlight change of color feature for the disease stain of leaf is absent green, we can use the color feature and its connectivity to implement the disease zone segmentation [1]. For this scheme, it has to determine an appropriate threshold to partition the goal zone from background such that to implement the zone segmentation.

Image segmentation of disease stain based on RGB [2]. From the observation of image pixel of disease example, the image color characteristic can be extracted as following expressions:

$$S_g = 2G - R - B \tag{1}$$

$$S_r = 2R - G - B \tag{2}$$

According the formula, the disease stain can be divided from the leaf.

Image segmentation of disease stain based on HIS. HIS color component is considerably suit to person optical rule, which carry out the discrimination according to the chroma, luminance, saturation of object and other complicated signal. HIS color component can be obtained by the transformation of RGB.

Principal component analysis (PCA) [3]. Linear methods project the high-dimensional data onto a lower transformation space, which can reduce the dimensionality by combining features. One of these methods is known as Principal Component Analysis or PCA, it seeks a projection that best represents the data in a least-squares sense. For a set of n dimensional samples $x_1,\ldots,x_n$, we want to find a vector x_0 such that the sum of the squared distances between x_0 and the various x_k is as small as possible. The squared-error criterion function is defined by

$$J_0(x_0) = \sum_{k=1}^{n} \|(x_0 - x_k)\|^2 \tag{3}$$

which is to seek the value of x_0 that minimizes J_0. The solution of the problem is $x_0 = m$, where m is the sample mean,

$$m = \frac{1}{n}\sum_{k=1}^{n} x_k \quad (4)$$

$J_0(x_0)$ is minimized by the choice $x_0 = m$. One-dimensional representation can be obtained by projecting the data onto a line running through the sample mean. e is the unit vector in the direction of the line. Then the line can be written as

$$x = m + ae \quad (5)$$

Where e is the vector in the direction of the line, then

$$x_k = m + a_k e \quad (6)$$

It is to find the optimal set of coefficient a_k by minimizing the squared-error criterion function, namely,

$$a_k = e^t(x_k - m) \quad (7)$$

It can obtain a least-squares solution by projecting the vector x_k onto the line in the direction of e that pass through the sample mean. The following problem is to find the best direction e for the line. It readily extend to a d'-dimensional projection, namely,

$$x = m + \sum a_i e_i \|(x_0 - x_k)\|^2 \quad (8)$$

We can rewrite the criterion function as

$$J_{d'} = \sum_{k=1}^{n} ||m - \sum_{i=1}^{d'} x_{ki} e_i||^2 \quad (9)$$

PCA reduces the dimensionality of feature space by restricting attention to those directions along which the scatter of the cloud is greatest.

B. Classifier training using Support vector machines (SVM)

SVM aims to train linear machine with margins. It relies on preprocessing the data to represent patterns in a high dimension than the original space. We first preprocess the features described above, and then to map them to a higher dimension space where they can be linearly separated. The goal is to find an appropriate nonlinear mapping $\varphi(\cdot)$ with a sufficiently high dimension to separate the data from two categories by a hyperplane [3]. Each pattern x_k can be transformed by $y_k = \varphi(x_k)$, for each pattern, $k = 1, 2, ..., n$, we let $z_k = \pm 1$, a linear discriminant is

$$g(y) = a^t y \quad (10)$$

The goal to train a SVM is to find the separating hyperplane with the greatest margin, such that to expect a better generalization of the classifier. The distance from any hyperplane to a pattern y_k is $|g(y)|/||a||$, and we assume a positive margin b exists,

$$\frac{z_k g(y_k)}{\|a\|} > b, k = 1, 2, ..., n \quad (11)$$

The ultimate goal is to find the weight vector a that maximizes b. For the problem of training an SVM, the first step is to select the nonlinear φ-functions that map the input to a higher-dimensional space; if we absence the knowledge of the problem domain, we might choose to use polynomials, Gaussians, or yet other basis functions. From the goal of minimizing $||a||$, we referred to the following function

$$L(a, \alpha) = \frac{1}{2}||a||^2 - \sum_{k=1}^{n} \alpha^k [z_k a^t y_k a^t y_k - 1] \quad (12)$$

And expect to minimize $L()$ with respect to the weight vector a, and maximize it with respect to the undetermined multipliers $\alpha_K \geq 0$.

4. Evaluation

In this section, we evaluate the performance of the current system, such that to check the validation of plant disease monitoring in our system. Because SVM seriously rely on the preprocessing of data, therefore our evaluation comprises two parts: (1) preprocessing feature extraction and (2) SVM training and testing.

A. Preprocess Feature Extraction

This goal in this stage is to train the feature vector, in our scheme, we plan to extract the feature for plant disease from two views, namely, color and PCA, which is listed in TABLE 1. Color feature extraction also involves two methods: (1) image segmentation based on RGB model, and (2) HSI model.

Table 1 Preprocessing feature extraction

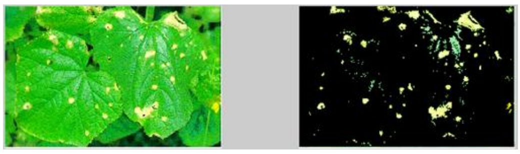
No.	View	Model Type
1	Color	RGB
2	Color	HSI
3	PCA	PCA

The training examples are shown in TABLE 2, they are divided into 3 teams, they comprise two categories, the first is the goal category, the other two ones is different category that are used to separate the distinct part. The test examples listed in TABLE 2 are collected by user mobile telephone in current system.

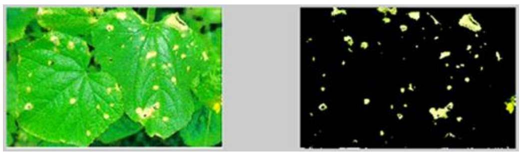
Table 2 Scheme of training examples

No.	category	Training(#)	Test(#)
1	Positive	500	260
2	Negative	500	240
3	Negative	500	250

In Figure 3, we use color model to implement the fleck segmentation for the plant disease. It can be found that the flecks of disease were separated from background accurately. The next step is to extract the profile feature from the above result, and construct the feature vector.



(a) Segmentation by RGB Model



(b) Segmentation by HSI Model

Figure 3 Feature segmentation by color model.

B. SVM training and testing

After carrying out the extraction of the feature according to TABLE 1, we can obtain 3 teams of feature vector, and then these vectors as input are referred to SVM process. Moreover, they are mapped to higher dimensional space such that to linearly be separated. The result of SVM process is a linear classifier. Once the classifier is ready, the test data listed in TABLE 2 are introduced to SVM classifier such that to test the classification effect. After the test, the test result is shown in the TABLE 3. From the results,

Table 3 Test result of SVM classifier

Class	Character	Test(#)	Matching rate
ω_1	Positive	260	0.95
ω_2	Negative	240	0.76
		250	0.66

it is apparent that two categories are separated considerably by classifier, which fairly demonstrates the validation of the classifier that is trained from our scheme.

5. Conclusion

In the present work, an automatic system for crop information monitoring is implemented, which comprises various function modules. Specially, in current system, a plant diseases detection scheme based on image segmentation is presented, it first carry out the preprocessing feature extraction, and then train a SVM classifier. The experimental results indicate that the system presented in this work can effectively monitor farm production information.

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Ming-Ming Xiao was born in 1972. He had received the B.As in Electronic Engineering from Hunan University, Changsha, China in 1996, and the M.As in Communication and Information System from Sun Yat-sen University, Guangzhou, China in 2003. He has been a candidate for PhD in Communication and Information System at Sun Yat-sen University since 2006. His current research interests include digital signal processing, digital image processing and computer network.