THE USE OF IMAGE PROCESSING TECHNOLOGY IN AGRICULTURAL PRODUCTION

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Özet

Son yıllarda dünyada bilgisayar kullanımının hızla yaygınlaşmasıyla, hemen hemen bütün bilim dallarında bilgisayar sistemleri uygulanmaktadır. Bu şekilde, istenilen sonuçlara daha hızlı, güvenilir az masraflı ve otomatik olarak ulaşılabilmektedir. Teknolojinin gelişmesiyle, insan gücü minimuma indirilmekte ve robotik çağ [1]gündeme gelmektedir. Bu durum gelişmiş ülkelerde daha çok belirgindir, fakat diğer gelişmemiş ülkelerde de bu konu üzerinde çalışmalar sürdürülmektedir. Geçtiğimiz 15 yıl boyunca tarımsal üretimde yeni algılama teknolojilerinin geliştirmesi ve uygulanması konusunda önemli ilerlemeler kaydedilmiştir. Bu yeni algılama teknolojileri, tarımsal üretimde etkili ve verimli bir şekilde ölçüm yapmak, incelemek, sınıflandırmak ve derecelendirmek için insan gücüyle yapılması zor ve zahmetli işleri rahatlıkla yapabilme olanağı sağlamıştır. Görüntü işleme teknolojisi ile tarımsal üretimde bitki hastalıkları, ekim mesafesi, toprak analizi, ürün sayısı gibi birçok alanda kullanıcının hayatını kolaylaştırmak için kullanılmaktadır. Tarım ürünlerinin sınıflandırılması, kalite özelliklerinin belirlenmesi ve kusurlarının saptanması gibi çeşitli çalışmalarda çok başarılı ve yüksek doğrulukla sonuçlar elde ettiren görüntüleme teknolojilerinin son yıllarda önemi oldukça artmaktadır. Tarımsal üretimin arttırılması amacıyla kullanılan görüntü işleme teknolojileri diğer yöntemlere göre daha az masraflı, ürüne zarar vermeyen, hızlı ve başarılı bir seçenektir. Görüntü işleme tekniğinde MATLAB, Python, ve JAVA gibi genel amaçlı programlama dilleri ile yazılan uygulamalar kullanılmaktadır. Bu çalışmada, görüntü işleme tekniklerinin tarımsal üretimdeki yeri ve öneminin değerlendirilmesi yapılmıştır.

Anahtar kelimeler: Bilgisayar, görüntü, işleme, MATLAB, Python, JAVA

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Abstract

With the rapid spread of computer use in the world in recent years, computer systems have been applied in almost all branches of science. In this way, the desired results can be achieved faster, reliably, cost-effectively, and automatically. With the development of technology, human power is being reduced to a minimum and the robotic era is coming to the agenda. This situation is more pronounced in developed countries, but studies are also being carried out on this issue in other undeveloped countries. Over the past 15 years, significant progress has been made in the development and application of new detection technologies in agricultural production. These new detection technologies have provided the opportunity to easily perform difficult and laborious tasks to be performed with human power to measure, examine, classify, and grade effectively and efficiently in agricultural production. With the help of image processing technology, it is used in agricultural production to facilitate the user's life in many areas such as plant diseases, October distance, soil analysis, and several products. The importance of imaging technologies, which have achieved very successful and highly accurate results in various studies such as classification of agricultural products, determination of quality characteristics, and detection of defects, has been increasing significantly in recent years. Image processing technologies used for the purpose of increasing agricultural production are a fast and successful option that is less costly than other methods and does not harm the product. Applications written in general-purpose programming languages such as MATLAB, Python, and JAVA are used in image-processing techniques. In this study, the place and importance of image-processing techniques in agricultural production were evaluated.

Keywords: Computer, image, processing, MATLAB, Python, JAVA

Introduction

Developing technological opportunities facilitate the life of human beings at every stage. Now, many operations such as topographic measurements on land, coordinate orthophotos, flood and flood damages, and yield measurement in agricultural areas are detected using image processing with various equipment.

The agricultural sector and the trade in agricultural products have always attracted the attention of politicians and academics due to the fact that it makes a significant contribution to the provision of foreign exchange necessary for the supply of industrial goods from abroad, which

play an important role in the growth and development of countries. Turkey has been liberalizing foreign trade since 1980, and in 1994, with the signing of the World Trade Organization (WTO) agreement on the liberalization of trade in agricultural products it slowly began to lose its character as a country self-sufficient in terms of agricultural products. Foreign trade deficit, the country's economy in terms of agricultural raw materials continuously since 1987, the first one being in 2000 until 2017 with a total of 7 times in total imports exceeded exports of agricultural products, thus, Turkey in respect of agricultural products, the self-among the countries has been inadequate (Çetin, 2020).

Grain production was 62.9 million tons in 2018, 63.8 million tons in 2019, 71.3 million tons in 2020, and 61.7 million tons in 2021. The year 2020 stands out as the year with the most production. The reason for the decline in 2021 is thought to be the COVID-19 effect. On the other hand, there is no decrease or increase in fruit production to be considered. Fruit production in 2018 was 22.3 million tons; in 2019, it was 22.3 million tons; in 2020, it was 23.6 million tons; in 2021, it was 24.9 million tons. Again, no noticeable change was recorded in vegetable and fruit production. It has a production of 30.8 million tons in 2018, 31.1 million tons in 2019, 31.2 million tons in 2020, 31 million tons in 2021, and 31 million tons in 2021 (FAO, 2021).

Image Processing

The agricultural industry is struggling with several challenges, including the maintenance and assurance of the quality and safety of agricultural products. Therefore, agricultural and food companies and their suppliers need effective, low-cost quality and safety control technologies to meet Sunday needs (Kamruzzaman et. al., 2015).

For this reason, computerized imaging systems in agriculture and food have recently gained considerable importance. In particular, image processing systems are used in the industry for quality control, compliance with standards, and increasing the market value of the product. It is observed that computerized imaging has been successfully applied in the objective determination of visual characteristics of foodstuffs, such as color density, color distribution, visible defects, dimensions, and shape (Omid et. al., 2010).

Image processing is replacing digital images with computer and software support for a specific purpose. Like other types of artificial intelligence, image processing aims to perform and automate tasks that replicate human capabilities. In this case, image processing tries to copy both the way people see and the way they make sense of what they see (Anonym, 2020a)

How to Analyze an Image with Image Processing

1) The detection device captures an image. This device is usually just a camera, but it can be a video camera, a medical imaging device, or any other machine that captures images for analysis.

2) The image is then sent to the interpretation device. The interpretation device uses pattern recognition to split the image, compare the patterns in the image with the known patterns library, and determine if any content in the image matches. The model can be generic, such as the appearance of a specific object, or it can be based on unique identifiers, such as facial features.

3) A user requests specific information about an image, and the interpretation device provides the requested information based on the analysis of the image (Wang and Sun, 2002).

Stages of Image Capture and Digitization

As a general term, image processing means manipulating and analyzing pictorial information (Anonym, 2022b). Some of the primary stages in this analysis can be summarized as follows: The first stage is the image acquisition process. In Figure 1, the image capture stages are roughly schematized. Here the object illuminated by a light source is present. The rays reflected from the object are transferred to the camera in optical form. These rays, which identify the object, are converted into electrical signals in the camera. Thus, the image is converted to analog format. Analog signals are converted into digital signals in a digital converter. In the last stage, the image converted to digital form is transferred to a computer environment and processed. For this process, an image sensor and systems that can transform the signals generated by this sensor into digital form are needed. If the signals obtained from the sensors are still in analog form, they can be digitized with analog-to-digital converters.

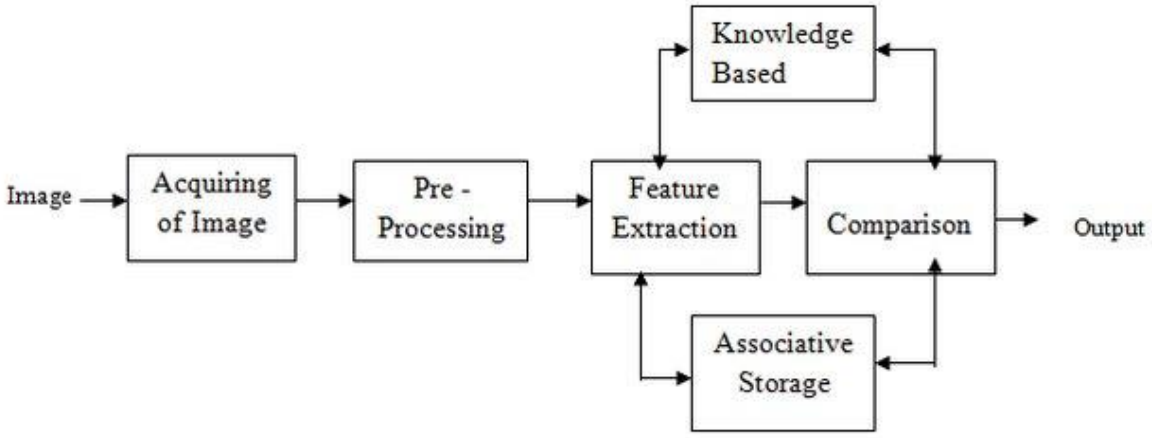


Figure 1. Image processing scheme(this figure by: Jessica Velasco)

After the digital image is obtained, the preprocessing process is done. At this stage, the received image is made more distinct and understandable so that it can be processed without errors and quickly at the next step. Some of these operations are:

-To make the image clearer,

-To filter the impurities contained in the image and

-To eliminate or minimize structural disturbances on the image.

Digital image processing (digital image process) or digital image analysis (digital image analysis) is the numerical expression of images of objects by imitating the functioning of the human visual system or obtaining results by digitizing analog information. Digital image processing is mainly used for brightness, contrast, color, etc., changing the information about the image, magnetic field, using incorrect hardware settings during viewing, etc. it refers to operations aimed at improving image quality (image enhancement), such as removing image impurities (noise) caused by causes, making details more distinct (sharpening). As a result, a new image is obtained. In digital image analysis, a new idea is usually not accepted due to the operations performed. Still, classifications of the image can be made, and statistics about the image are produced. In digital image analysis, the parameters of the objects (shape, length, area, angle, relative position, textural structure, gray-tone value, RGB color values, etc.) are concerned with measuring (Castelman, 1996).

Why is Image Processing Needed?

In recent years, computer-aided image processing techniques have developed rapidly. They have begun to be widely used in numerically determining agricultural product size, shape, color, and structural characteristics. Due to the accurate and consistent results obtained, image processing systems play a more critical role in the quality assessment of agricultural products daily and are replacing manual evaluations. These systems provide flexibility in application and replace visual inspections made by people with these features.

From the past years to the present, defective agricultural products are still detected in some enterprises by scanning controllers. Still, this process is unreliable and is very laborious and long-lasting. The importance of imaging technologies entering the agricultural industry to obtain more reliable results and reduce costs is increasing daily. Hyperspectral and multispectral imaging technologies are the most successful and generally preferred imaging technologies among various imaging technologies (Baxes, 1994).

Image Processing Techniques and Sustainable Agriculture

It is essential to meet the nutritional needs of the ever-increasing world population. For this purpose, in addition to increasing the amount of product obtained from the unit area, it is necessary to use the existing resources effectively. These are among the essential elements of today's agricultural policies. When agricultural activities are Deciphered, image processing techniques are used at almost every stage. The requirements of sustainable agriculture are; effective resource use, waste assessment, increasing the diversity of agricultural activities, and efficiency in product processing are also frequently encountered in research where image processing techniques are used (Du and Sun, 2004).

Image processing techniques contribute to the health of sustainable agriculture, especially in the direction of increasing the effectiveness of agricultural inputs such as water, fertilizers, pesticides, and land use. In addition, proper soil preparation, as well as at the cultivation stage, the use of quality seeding, crop processing, storage, etc., are frequently used in pre- and post-cultivation applications (Baxes, 1994; Du and Sun, 2004).

Image Processing Techniques in Irrigation and Fertilization Applications

Water is vital for the survival of living things. The decrease in usable water, while the increase in the world's population, increases the importance of water day by day. In our country, 74% of freshwater resources are used in agricultural activities (FAO, 2003).

For this reason, especially in agriculture, it is necessary to use water effectively and protect the existing water. Thus, a significant contribution can also be made to sustainable agriculture. In the literature, there are studies in which image-processing applications are used that directly aim at the effective use of water.

In addition, there are also research topics that serve this purpose with secondary outputs. These investigations are the determination of the cultivated plant, the decision of the maturity status, the determination of the watering time, etc., which concentrates on applications.

Brassica Napus (B. napus) rapeseed species are intended to be separated according to important characteristics such as flower, leaf, and package. It has adopted two types of rapeseed, such as B. Rapa and B. Alba. Five contemporary deep learning-based Convolutional Neural Network (CNN) models were also evaluated to classify rapeseed species. As a result of this study, both species were successfully classified with an accuracy rate of 100% for flowers and 97% for both packages and leaves. (M Alom et al., 2023)

In another study, it was aimed to use a plant image processing method combined with the BP neural network to determine the disease level of Brassica napus. As an experimental result of the study, it was determined that the average squared error of the classification network for brassica olerica was 0.049, and the accuracy rate of the classification results predicted by the model was about 93%, and it was deemed appropriate to use image processing technique to determine the degree of disease. (D Jiang et al., 2022)

Image processing techniques are preferred in studies focusing on saving water at the desired time, in sufficient quantities, such as irrigation to the desired target. Many similar studies can also be used in fertilization activities. Therefore, image processing techniques increase the effectiveness of fertilizer use and water (Onur and Malaslı, 2016).

They examined the wilting condition in a study, an essential symptom of water stress in plants. For the detection of this symptom, they used laser distance measurement technology. Thus, they revealed the leaf's two-dimensional physiology and examined the wilting state. The researchers have achieved acceptable success in the early diagnosis of water stress with the application (Cai et al., 2003).

They studied to determine the surface covering an area of the lettuce plant during the 97-day vegetation phase. They have realized the separation of lettuce plant and land surface by

reducing it to the binary color level of black and white. Thus, the researchers determined the surface coating area of the plant and tried to determine the plant water consumption need based on the coating area. Researchers who have achieved successful results in this regard, in addition to water, fertilizer, etc., with the method used. The inputs stated that effective use could be provided according to the plant's needs (Pacheco et. al., 2014).

Image Processing Techniques in Pre- and Post-cultivation Applications

In agricultural activities, as in the cultivation phase, proper soil preparation, good variety selection, use of quality seed, product processing, storage, etc., image processing techniques are also frequently used in pre- and post-cultivation applications.

They used image processing techniques to determine the line over the row in sweetcorn. Researchers working on black and white images in which green areas are captured aim to instantly detect the line over the row passing through these areas and to reveal the success of detection. In the study, they evaluated the application success of different image resolutions. They stated that more successful results were obtained at high resolution in determining the over-row line, while the detection time decreased at low resolution (Jiang et al., 2015).

Image processing techniques provide high precision and fast answers to the needs in this field. In addition, there are also outputs such as increasing productivity, improving quality, and reducing costs. With these characteristics, it is observed that the application also has essential contributions to sustainable agriculture in pre- and post-cultivation activities (Onur and Malaslı, 2016).

Some Studies in Agriculture with Image Processing

In engineering studies related to the evaluation of agricultural products, knowing the dimensional characteristics of the product is an essential parameter for the design of machinery related to the product. On the other hand, it is possible to determine the dimension properties using appropriate calculations and experimental methods.

This study, it was aimed to develop and test a series of measurements to determine the plant wilting that will occur in response to abiotic stress caused by factors such as heat or drought or biotic stress caused by pathogenic microorganisms. As a result of these measurements, it was thought that they could be useful in genomic studies to detect the genes and genomic regions underlying plant resistance to specific stress. Two different data were used in the study: one

pathogen-injected tomatoes and the other soybeans exposed to water stress. As a result of the study, it was found that image-based fading measurements can be useful to determine the fading of plants caused by different stresses in various plant species. (C Yang et al., (2023)

Another study, it was aimed to obtain harvest estimation by artificial intelligence from apple tree image pixels taken using computer image processing methods. Linear regression (LR) method, convolutional neural networks (CNN), artificial neural network (ANN) model and three different artificial intelligence tools were used in the study. As a result of the study, an accuracy rate of more than 95% was determined in the prediction of the harvested apples, while the prediction rate performed on the tree is lower. An accuracy rate of more than 85% has been determined in the trees that have been tested on. When considered as a method, it has been observed that the most successful method is CNN and the prepared artificial neural network. (Şule and Kayabaşı, (2023)

It is aimed to detect powdery mildew disease in the domain based on a data set collected in a real-time scenario. As a result, maximum values such as 89.19% and 88.57% were determined with the IMPS technique, which is the best among the different techniques used, and it was determined that plant diseases can be injured by image processing in the prediction. (A Bhatia et al., 2020)

It is aimed to detect leaf disease by using deep learning and feature selection methods. For the method determined for this purpose, 726 images consisting of walnut leaves were collected. These images were created in two different classes healthy and diseased. Two different tools DarkNet53 and ResNet101 were used in the study. With the proposed method, a high accuracy rate of 99.58% has been achieved. (Yaman and Tuncer, 2022)

In their research, they examined the detection of grape clusters during the harvest period in the vineyard environment. At this stage, they took advantage of the differences in color parameters. As a result of the research, they emphasized that they achieved 91% and 97% panicle detection success in white and red grapes, respectively (Reis et al., 2012).

In a study, when the surface area of apple measured with a planimeter and obtained by image processing technique was examined, the common variance value between the two methods was found to be insignificant, with a value of 207.261 and the deficiency of the t-test with a value of 0.578. In light of these values, it can be said that apple surface areas can be safely determined

by the image processing method. Different methods can also be used to determine the "surface area," which is one of the dimensional properties. However, due to the fact that the shape and size characteristics of the products are in a wide range, it is inevitable to use product-specific methods (Işık and Güler, 2003).

Images of peeled salak (Salacca zalacca) fruits were taken at the beginning of storage and every 12 hours during storage. The images were obtained with a resolution of 400x300 pixels and 256 colors. The resulting images were then analyzed using a program developed to determine and calculate the percentage of the damaged area. First of all, the program calculated the area of the peeled idiot fruit by giving it a single threshold level. Then the program detected and calculated the area of the bruise using only the double threshold levels, where the Decayed area is between the two threshold levels. The entire area was removed from the bruised area to obtain the non-bruised area. The percentage of the non-carious area was obtained by dividing the area of the non-carious part by the area of the whole peeled clod. In each salak fruit, the development of the bruised area every 12 hours during storage was calculated using image processing (Ahmad et. al., 2001).

In a study conducted on the detection of stains in apples and their classification by image processing technique, software was developed with the help of the MATLAB program. In the conducted study, 7 out of 10 stained apples were detected. There was no problem with the color and size classification of the different color apples photographed by the software (Du and Sun, 2004).

Product	**Purpose of study**	**Researches**
Sweet cherry	**Analysis of shapes**	**Beyer et al., 2002**
Tea	**Classification**	**Li et al., 2011**
Sweet cherry	**Classification**	**Balcı et al., 2016**
Nuts	**Classification**	**Solak and Altinişik, 2018**
Weed	**Determination of Weed**	**Şin and Kadıoğlu, 2019**

Apple	**Determination of Diseases**	**Rehman et al., 2021**
Grape	**Determination of Diseases**	**Altaş et al., 2021**
Peach	**Leaf Diseases Identification**	**Zhang et al., 2023**

Table 4. Studies conducted using image processing technology

Results

According to the research results, image processing technologies can be applied effectively in the agricultural industry and in other sleeping areas. The importance of imaging technologies, which provide very successful and high-accuracy results in various studies, such as the classification of agricultural products, determination of quality characteristics, and detection of defects, has been increasing significantly in recent years.

Image processing technologies used to increase agricultural production are a fast and successful option that is less expensive than other methods, does not harm the product, and is a quick and successful option.

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