Vision technology in practice

Vision technology enables more and more internal and external quality characteristics to be inspected: from shape and colour properties to photosynthesis and content substances. The technology is being increasingly used in the floriculture sector as an aid in quality sorting and to control robots. Here is an overview of the 'state of the art' vision technology for practical applications.

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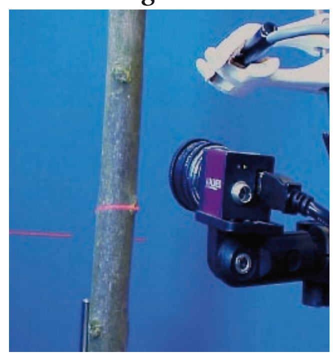
For many years, 2 dimensional (2D)-technology has been used to sort potted plants and prick out young plants. The plants are transported past one or more cameras and are inspected using 2D-geometric characteristics including height, width, area, number of flowers and shape. Demands are becoming increasingly specific and the plant breeding sector has discovered vision technology as well. Calibrated colour measurements, shoot formation, leaf and flower positions, and leaf and flower shapes can now be measured automatically and, in the flower sector, it seems that more 2D-vision leaps forward are now possible.

2D-cameras are also used to control robots. Christmas cactus cuttings, for instance, are photographed and the information processed using software. A robot gripper picks up the Christmas cactus cutting exactly in the right place, in the right alignment and puts it into a plug. As far as harvesting fruit and vegetables, plenty of experience has already been gained with cameras combined with robots.

New technology is also making the use of cameras easier. Cheaper and more robust solutions are available in the form of the 'smartcam'. This is a standardised combination of a camera and PC. The advantage is that you no longer need any individual interference-sensitive PCs or PLCs for data processing and controlling the machine's hardware. The smartcam can do this. For example, you can align orchids automatically for an investment of €15,000. The market for low-budget solutions is also dynamic.

It looks as if the various 3D techniques are also becoming available to the flower sector. There are techniques that can make a height profile from one aspect. This technology is also called 2½D, because the back cannot be seen from one aspect. Examples of these techniques are: Laser triangulation, stereovision and Time of Flight cameras.

Laser triangulation and Time of Flight cameras

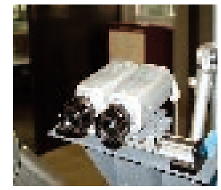


In laser triangulation, a moving laser line or a laser grid is combined with a camera. A camera 'looks' at an object from an angle in relation to the laser and 'sees' a height profile. A height profile can be distilled from this action. By using several cameras and lasers from different angles, a complete 3D image can be created.

Possible laser triangulation applications are structures with a homogeneous colour. Some examples include counting the number of pepper segments; tracking a stem to adjust a robot, which is used with roses, for instance; determining the leaf diameter of wavy leaves on plants including anthurium, cup shaped gerberas and leafs of monstera. A technique that offers similar possibilities is the Time of Flight camera (TOF camera). A Time of Flight camera is a camera system that creates distance data using the Time of Flight (TOF) principle. Both techniques basically generate a 2½D height image from one aspect.

Stereovision

In stereovision there are two cameras of



which each makes an image of an object. The distance between the cameras and the shift of the images in relation to each other, give depth information. If an object is infinitely far away, the two camera images unite to form one picture. If the images have shifted considerably in relation to each other, the object is nearby. Two strategies can be distinguished here. In practice, relevant objects are usually identified and matched (object matching) in the separate images, but it is also possible to match the total image structures.

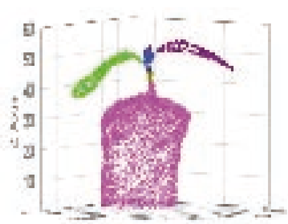
A possible application for this technique is making good and fast depth images to control robots. One example used in a practical situation is the rose harvesting robot produced by Jentjens. (picture below) A robot measures the ripeness and position. The robot with the stereovision system grasps the head, then looks down the stem with two cameras to reach the point where it finds the right length for the stem to be

cut. This technology has also been applied in robots for cucumbers, tomatoes and hard fruit and gives a 2½ image.

Volumetric intersection

In volumetric intersection, an object rotates in front of a camera that makes several images or in front of several cameras that record an image at one particular moment under different angles. Each time, the software cuts away any space that does not contain an object. Software can reconstruct a complete 3D-model of the plant, including even its colour. This technology is still in its infancy. The first applications can be expected with counting freesia and orchid buds (quality characteristic) and determining the growing point and measuring the exact leaf area and the length of stems in seedlings.

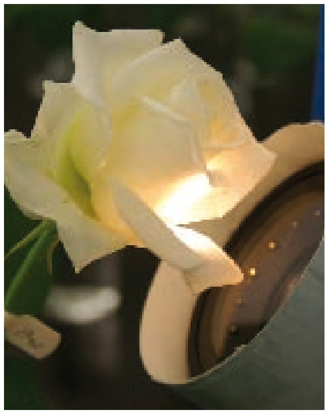
The technology to create beautiful 3D-images is available, but segmentation is still lacking. Wageningen UR is working hard on a toolbox that will enable the different characteristics to be measured in 3D.



An image of the inside

In addition to the visible area, there are also ways to look at flowers and plants with cameras using a wider spectrum of light. This makes it possible to look inside the plant as well.

Beside the black/white or



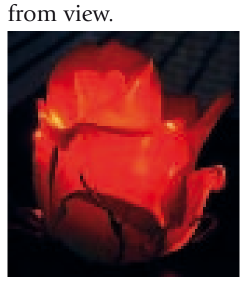
RGB-cameras (red green blue), there are the multi-spectral cameras, containing sensors that are sensitive to many more wave lengths inside and outside from what is visible. This creates even more applications that also provide information about an object's internal properties.

A multi-spectral camera can contain 4 to 300 spectral bands from far-infrared to far-UV. In NIR-spectrometry (Near Infra Red), a white light beam is directed towards an object. Every 'content substance' absorbs the wave lengths that are specific to a particular substance. A camera can look at the transmitted light or the reflected light. Comparing the product's wave length pattern with that of known reference substances shows whether these substances are present and in what quantity. This can be done by means of point measurement, but increasingly also by showing the properties of the total product.
Applications: determining content substances. Every substance has its own pattern of absorbed peaks. It is therefore possible, for instance, to determine the lycopene content of tomatoes as a quality characteristic and to use this in a tomato sorting machine. Other content substances that can be measured include ß-carotene, chlorophyll-A, protein and sugar content.

Another possibility is determining the nutritional condition of a plant in order to administer the necessary fertilisers.

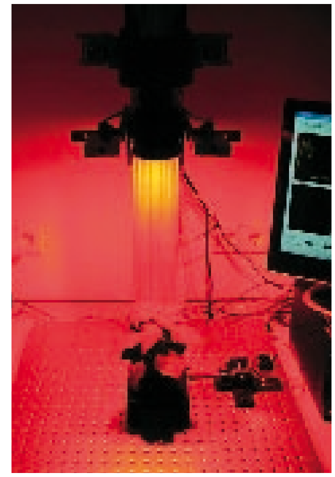
X-rays

X-ray technology is now also making a breakthrough in the greenhouse horticulture sector. The technology makes it possible to look through leaves, seeds, bulbs and structures on the basis of density measurement. X-ray technology provides information about hidden properties. Based on density, it is possible to determine for instance how many successive alstroemeria or orchid flowers are on a single stem. Flower grading lines are now being constructed with integrated X-ray systems that count tulips and alstroemerias on the basis of flower buds and bud height. These buds are among the leaves and normally hidden from view.



Chlorophyll fluorescence

Chlorophyll fluorescence is today's great all-rounder for vegetative material. This tool is much in demand as it can determine the photosynthetic activity of plants. In chlorophyll fluorescence, a red laser



beam is directed towards the object. Chlorophyll strongly reacts under red light. A camera records the fluorescent image.

Recording one image with a red laser and one without, then subtracting these images from each other using software, produces an image of a product's photosynthetic activity. Plants suffering from stress or disease, such as Botrytis, show 'dead', black spots where the chlorophyll does not react. In the future, it will probably be possible to diagnose the disease concerned based on the pattern. Other stress factors can also be detected well via this technique.

The technology has a lot of potential and can also be used in determining product shelf life. Living produce produces chlorophyll and decomposes it. The quantity of chlorophyll produced is indicative of the shelf life of the produce in question. The technology can be used, for instance, for strawberries, flowers, and vegetables. Since different plant parts fluoresce in different ways, there are also applications conceivable for counting flowers, stems and leaves. ■