PROYECTO FIN DE GRADO

TÍTULO: Detection And Pattern Recognition Applied To Leaves And Chromosomes

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Resumen

El proyecto que se puede ver a continuación trata sobre las tecnologías empleadas en la detección y reconocimiento de objetos, especialmente de hojas y cromosomas.
Para ello, este documento contiene las partes típicas de un paper de investigación, puesto que es de lo que se trata. Así, estará compuesto de Abstract, Introducción, diversos puntos que tengan que ver con el área a investigar, trabajo futuro, conclusiones y biografía utilizada para la realización del documento.

Así, el Abstract nos cuenta qué vamos a poder encontrar en este paper, que no es ni más ni menos que las tecnologías empleadas en el reconocimiento y detección de patrones en hojas y cromosomas y qué trabajos hay existentes para catalogar a estos objetos.

En la introducción se explican los conceptos de qué es la detección y qué es el reconocimiento. Esto es necesario ya que muchos papers científicos, especialmente los que hablan de cromosomas, confunden estos dos términos que no podían ser más sencillos. Por un lado tendríamos la detección del objeto, que sería simplemente coger las partes que nos interesasen de la imagen y eliminar aquellas partes que no nos fueran útiles para un futuro. Resumiendo, sería reconocer los bordes del objeto de estudio.
Cuando hablamos de reconocimiento, estamos refiriéndonos al proceso que tiene el ordenador, o la máquina, para decir qué clase de objeto estamos tratando.

Seguidamente nos encontramos con un recopilatorio de las tecnologías más utilizadas para la detección de objetos, en general. Aquí nos encontraríamos con dos grandes grupos de tecnologías: Las basadas en las derivadas de imágenes y las basadas en los puntos ASIFT.
El grupo de tecnologías basadas en derivadas de imágenes tienen en común que hay que tratar a las imágenes mediante una convolución con una matriz creada previamente. Esto se hace para detectar bordes en las imágenes que son básicamente cambios en la intensidad de los píxeles. Dentro de estas tecnologías nos encontramos con dos grupos: Los basados en gradientes, los cuales buscan máximos y mínimos de intensidad en la imagen puesto que sólo utilizan la primera derivada; y los Laplacianos, los cuales buscan ceros en la intensidad de los píxeles puesto que estos utilizan la segunda derivada de la imagen. Dependiendo del nivel de detalles que queramos utilizar en el resultado final nos decantaremos por un método u otro puesto que, como es lógico, si utilizamos los basados en el gradiente habrá menos operaciones por lo que consumirá más tiempo y recursos pero por la contra tendremos menos calidad de imagen. Y al revés pasa con los Laplacianos, puesto que necesitan más operaciones y recursos pero tendrán un resultado final con mejor calidad.
Después de explicar los tipos de operadores que hay, se hace un recorrido explicando los distintos tipos de algoritmos que hay en cada uno de los grupos.
El otro gran grupo de tecnologías para el reconocimiento de objetos son los basados en puntos ASIFT, los cuales se basan en 6 parámetros de la imagen y la comparan con otra imagen teniendo en cuenta dichos parámetros. La desventaja de este método, para nuestros propósitos futuros, es que sólo es valido para un objeto en concreto. Por lo que si vamos a reconocer dos hojas diferentes, aunque sean de la misma especie, no vamos a poder reconocerlas mediante este método. Aún así es importante explicar este tipo de tecnologías puesto que estamos hablando de técnicas de reconocimiento en general.
Al final del capítulo podremos ver una comparación con los pros y las contras de todas las tecnologías empleadas. Primeramente comparándolas de forma separada y, finalmente, compararemos todos los métodos existentes en base a nuestros propósitos.

Las técnicas de reconocimiento, el siguiente apartado, no es muy extenso puesto que, aunque haya pasos generales para el reconocimiento de objetos, cada objeto a reconocer es distinto por lo que no hay un método específico que se pueda generalizar.

Pasamos ahora a las técnicas de detección de hojas mediante ordenador. Aquí usaremos la técnica explicada previamente explicada basada en las derivadas de las imágenes. La continuación de este paso sería diseccionar la hoja en diversos parámetros. Dependiendo de la fuente a la que se consulte pueden haber más o menos parámetros. Unos documentos aconsejan dividir la morfología de la hoja en 3 parámetros principales (Forma, Dentina y ramificación) y derivando de dichos parámetros convertirlos a 16 parámetros secundarios. La otra propuesta es dividir la morfología de la hoja en 5 parámetros principales (Diámetro, longitud fisiológica, anchura fisiológica, área y perímetro) y de ahí extraer 12 parámetros secundarios. Esta segunda propuesta es la más utilizada de todas por lo que es la que se utilizará.

Pasamos al reconocimiento de hojas, en la cual nos hemos basado en un documento que provee un código fuente que clicando en los dos extremos de la hoja automáticamente nos dice a qué especie pertenece la hoja que estamos intentando reconocer. Para ello sólo hay que formar una base de datos. En los test realizados por el citado documento, nos aseguran que tiene un índice de acierto del 90.312% en 320 test en total (32 plantas insertadas en la base de datos por 10 test que se han realizado por cada una de las especies).

El siguiente apartado trata de la detección de cromosomas, en el cual se debe de pasar de la célula metafásica, donde los cromosomas están desorganizados, al cariotipo, que es como solemos ver los 23 cromosomas de forma ordenada.
Hay dos tipos de técnicas para realizar este paso: Por el proceso de esquelotonización y barriendo ángulos. El proceso de esqueletonización consiste en eliminar los píxeles del interior del cromosoma para quedarse con su silueta; Este proceso es similar a los métodos de derivación de los píxeles pero se diferencia en que no detecta bordes si no que detecta el interior de los cromosomas. La segunda técnica consiste en ir barriendo ángulos desde el principio del cromosoma y teniendo en cuenta que un cromosoma no puede doblarse más de X grados detecta las diversas regiones de los cromosomas.

Una vez tengamos el cariotipo, se continua con el reconocimiento de cromosomas. Para ello existe una técnica basada en las bandas de blancos y negros que tienen los cromosomas y que son las que los hacen únicos. Para ello el programa detecta los ejes longitudinales del cromosoma y reconstruye los perfiles de las bandas que posee el cromosoma y que lo identifican como único.

En cuanto al trabajo que se podría desempeñar en el futuro, tenemos por lo general dos técnicas independientes que no unen la detección con el reconocimiento por lo que se habría de preparar un programa que uniese estas dos técnicas.
Respecto a las hojas hemos visto que ambos métodos, detección y reconocimiento, están vinculados debido a que ambos comparten la opinión de dividir las hojas en 5 parámetros principales. El trabajo que habría que realizar sería el de crear un algoritmo que conectase a ambos ya que en el programa de reconocimiento se debe clicar a los dos extremos de la hoja por lo que no es una tarea automática.
En cuanto a los cromosomas, se debería de crear un algoritmo que busque el inicio del cromosoma y entonces empiece a barrer ángulos para después poder dárselo al programa que busca los perfiles de bandas de los cromosomas.

Finalmente, en el resumen se explica el por qué hace falta este tipo de investigación, esto es que con el calentamiento global, muchas de las especies (tanto animales como plantas) se están empezando a extinguir. Es por ello que se necesitará una base de datos que contemple todas las posibles especies tanto del reino animal como del reino vegetal. Para reconocer a una especie animal, simplemente bastará con tener sus 23 cromosomas; mientras que para reconocer a una especie vegetal, existen diversas formas. Aunque la más sencilla de todas es contar con la hoja de la especie puesto que es el elemento más fácil de escanear e introducir en el ordenador.

Summary

The Project you are about to see it is based on the technologies used on object detection and recognition, especially on leaves and chromosomes.
To do so, this document contains the typical parts of a scientific paper, as it is what it is. It is composed by an Abstract, an Introduction, points that have to do with the investigation area, future work, conclusions and references used for the elaboration of the document.

The Abstract talks about what are we going to find in this paper, which is technologies employed on pattern detection and recognition for leaves and chromosomes and the jobs that are already made for cataloguing these objects.

In the introduction detection and recognition meanings are explained. This is necessary as many papers get confused with these terms, specially the one's talking about chromosomes. Detecting an object is gathering the parts of the image that are useful and eliminating the useless parts. Summarizing, detection would be recognizing the object's borders.
When talking about recognition, we are talking about the computers or the machines process, which says what kind of object we are handling.

Afterwards we face a compilation of the most used technologies in object detection in general. There are two main groups on this category: Based on derivatives of images and based on ASIFT points.
The ones that are based on derivatives of images have in common that convolving them with a previously created matrix does the treatment of them. This is done for detecting borders on the images, which are changes on the intensity of the pixels. Within these technologies we face two groups: Gradian based, which search for maximums and minimums on the pixels intensity as they only use the first derivative. The Laplacian based methods search for zeros on the pixels intensity as they use the second derivative. Depending on the level of details that we want to use on the final result, we will choose one option or the other, because, as it's logic, if we used Gradian based methods, the computer will consume less resources and less time as there are less operations, but the quality will be worse. On the other hand, if we use the Laplacian based methods we will need more time and resources as they require more operations, but we will have a much better quality result. After explaining all the derivative based methods, we take a look on the different algorithms that are available for both groups.
The other big group of technologies for object recognition is the one based on ASIFT points, which are based on 6 image parameters and compare them with another image taking under consideration these parameters. These methods disadvantage, for our future purposes, is that it is only valid for one single object. So if we are going to recognize two different leaves, even though if they refer to the same specie, we are not going to be able to recognize them with this method. It is important to mention these types of technologies as we are talking about recognition methods in general.
At the end of the chapter we can see a comparison with pros and cons of all technologies that are employed. Firstly comparing them separately and then comparing them all together, based on our purposes.

Recognition techniques, which are the next chapter, are not really vast as, even though there are general steps for doing object recognition, every single object that has to be recognized has its own method as the are different. This is why there is not a general method that we can specify on this chapter.

We now move on into leaf detection techniques on computers. Now we will use the technique explained above based on the image derivatives. Next step will be to turn the leaf into several parameters. Depending on the document that you are referring to, there will be more or less parameters. Some papers recommend to divide the leaf into 3 main features (shape, dent and vein) and doing mathematical operations with them we can get up to 16 secondary features. Next proposition is dividing the leaf into 5 main features (Diameter, physiological length, physiological width, area and perimeter) and from those, extract 12 secondary features. This second alternative is the most used so it is the one that is going to be the reference.

Following in to leaf recognition, we are based on a paper that provides a source code that, clicking on both leaf ends, it automatically tells to which specie belongs the leaf that we are trying to recognize. To do so, it only requires having a database. On the tests that have been made by the document, they assure us a 90.312% of accuracy over 320 total tests (32 plants on the database and 10 tests per specie).

Next chapter talks about chromosome detection, where we shall pass the metaphasis plate, where the chromosomes are disorganized, into the karyotype plate, which is the usual view of the 23 chromosomes ordered by number.
There are two types of techniques to do this step: the skeletonization process and swiping angles. Skeletonization progress consists on suppressing the inside pixels of the chromosome to just stay with the silhouette. This method is really similar to the ones based on the derivatives of the image but the difference is that it doesn't detect the borders but the interior of the chromosome.
Second technique consists of swiping angles from the beginning of the chromosome and, taking under consideration, that on a single chromosome we cannot have more than an X angle, it detects the various regions of the chromosomes.

Once the karyotype plate is defined, we continue with chromosome recognition. To do so, there is a technique based on the banding that chromosomes have (grey scale bands) that make them unique. The program then detects the longitudinal axis of the chromosome and reconstructs the band profiles. Then the computer is able to recognize this chromosome.

Concerning the future work, we generally have to independent techniques that don't reunite detection and recognition, so our main focus would be to prepare a program that gathers both techniques.
On the leaf matter we have seen that, detection and recognition, have a link as both share the option of dividing the leaf into 5 main features. The work that would have to be done is to create an algorithm that linked both methods, as in the program, which recognizes leaves, it has to be clicked both leaf ends so it is not an automatic algorithm.
On the chromosome side, we should create an algorithm that searches for the beginning of the chromosome and then start to swipe angles, to later give the parameters to the program that searches for the band profiles.

Finally, on the summary, we explain why this type of investigation is needed, and that is because with global warming, lots of species (animals and plants) are beginning to extinguish. That is the reason why a big database, which gathers all the possible species, is needed. For recognizing animal species, we just only have to have the 23 chromosomes. While recognizing a plant, there are several ways of doing it, but the easiest way to input a computer is to scan the leaf of the plant.

Detection and Pattern Recognition Applied to Leaves and Chromosomes

Alexander Armstrong Cottle Cabildo

ABSTRACT

Leaves and chromosomes, chromosomes and leaves; at first sight both words don't have anything in common, but when talking about species things start to match. While talking about the animal kingdom, chromosomes are the identity of every single species that conforms this group. While talking about leaves, the same is said for the plant kingdom.
In this paper we will see different detection and pattern recognition methods that we can possibly apply for leaf and chromosome classification.

1. INTRODUCTION

While trying to get classification of several objects by computer processing, we first have to recognize the object that we want to classify. As soon as we have this object, it is the turn to search for some patterns that can identify which object is and classify it in a proper way.
Thus, to achieve proper classification we have two stages, the first one is Detection where we are going to eliminate all the background or non useful things which are not relevant, sticking to the object itself; The second stage implies pattern recognition where the computer is going to search for some predefined patterns (manual input or learned by the computer itself) and try to give a classification of the object that has been analyzed. In this paper we will concentrate on chromosome and leaf recognition, but there are too many other fields in which these same stages are shared, such as facial recognition, text recognition, etc.

While doing detection of the object, the most common technique that is used is to encounter the edge. According to [G] "Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene".

According to [A] "Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest from their background, and make sound and reasonable decisions about the categories of the patterns."

As said before, in this paper we will only focus on the methods used in detection and pattern recognition applied to leaves and chromosomes for further classification. We will also discuss the advantages and disadvantages that have both stages and the difficulties implied in the process.

2. MORE INFORMATION ABOUT TECHNOLOGIES USED IN DETECTION

In this chapter we will see different technologies employed on detection methods of all kinds of objects.

2.1 Detection based on derivatives of images

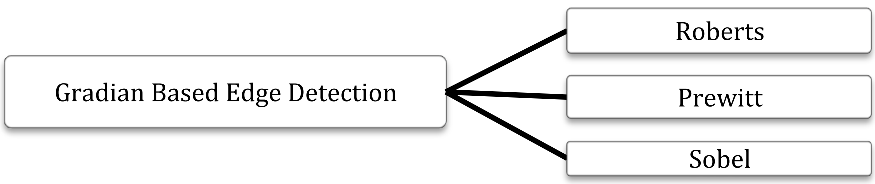
When talking about detection, the most common used technique is the edge detection. As said by [G] and [H] there are two main groups when it comes to classify the several methods of edge detection.

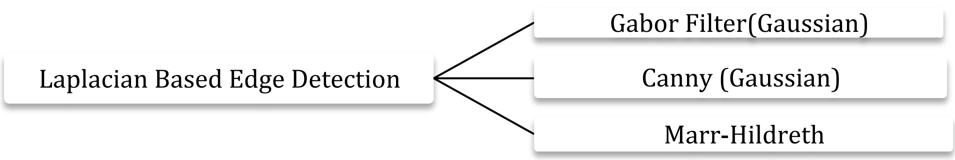
- **Gradian based edge detection**: These types of methods derivative the whole image pixels, in order to find maximum and minimum of this pixels to then, find the edge.
- **Laplacian based edge detection**: These types of methods use the second derivative to search for zeros on the image.

This methods are based on the derivatives of the image as the edges of the object normally have a higher intensity than the surrounding pixels (background or the inside part of the object) so if we derivate the image, we will be able (most of the times) to quickly encounter the edge of the object.

Groups of methods have several problems while detecting edges, mostly, due to the noise but they also can detect false edges, they sometimes can't detect true edges. Because of this, sometimes edges are thinner or thicker than the expected result and the algorithm has to process the result in order to get the expected result.

We can find different implementations of these groups; next schemes show some possible algorithms within their group:





Main Differences between both groups are the sacrifice between complexity and efficiency. While Gradian Based Edge Detection methods are much more simple (as they only require one derivative to do the whole process) they are less effective as they only take under consideration one operation. On the other hand, Laplacian Based Edge Detection methods are much more effective but they require a higher time of operation and more computer resources.

Concerning that, we will now take a close look into the different algorithms and how do they work:

2.1.1 Robert's Operator

This operator uses two simple 2x2 matrixes to respond to the edges that run on 45º relative to the pixel grid. Each matrix responds to one outside of the edge (background or inside of the object). The matrixes are the same but rotated 90º to responds as we have said.

$$\begin{matrix} 1 & 0 \\ 0 & -1 \end{matrix} \qquad \begin{matrix} 0 & 1 \\ -1 & 0 \end{matrix}$$

2.1.2 Prewitt Operator

This operator uses two simple 3x3 matrixes to respond in a 2-D dimension to the edges. This is vertically and horizontally. The difference with Robert's operator is that this one takes under consideration the four 90º running out of the edge. The second matrix is, once again, rotated 90º respect from the other one. The matrixes are defined as follows:

$$\begin{matrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{matrix} \qquad \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix}$$

2.1.3 Sobel Operator

It is really similar to Prewitt's Operator, the only difference that we can see is in the coefficients used in the matrixes; But the functionality is the same, they take under consideration the four 90º running out of the edge as well. The matrixes are defined as follows:

$$\begin{matrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{matrix} \qquad \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix}$$

2.1.4 Gabor Filter (Gaussian)

These filters are similar to the ones that human beings have to appreciate textures. It is based on a Gaussian Matrix, which is modulated by a sinusoidal plane wave. So starting on that, these filters can be part of Gaussian wavelets, which are designed for a number of dilations and rotations. As this operation is time consuming, it is useful to create filters, which will convolve to create a "Gabor space".

2.1.5 Canny Filter (Gaussian)

It is known to be the optimal edge detector, as it enhances all the approaches that we can see in this paper with a really successful result.
To implement the Canny algorithm the first step to take is to filter all the possible noise that is in the image. To do so, a Gaussian filter is calculated for the image and it is convolved with it. The filter is smaller than the original image and its width affects to the sensibility or to the noise.
Sobel Operator takes now part to detect the gradient of the edges on the image. The matrixes are the same as the ones we have explained before, so the result is the same as the operator gives the gradients horizontally and vertically. Normally, the X and the Y have an Absolut value that differs from zero, but sometimes X is equal to zero so depending on the Y edge, the edge direction will be 0 or 90º. To estimate the value of the edge direction we have to use the next formula:

$$\theta = \tan^{-1}\frac{Gy}{Gx}$$

Where θ is the edge direction, Gx is the X value and Gy is the Y value.

Once the direction is known we have to convert it in a 2-D scale, so every pixel can take four different values:

- 0 degrees if the pixel is on an horizontal direction (0 to 22.5 & 157.5 to 180 degrees)
- 45 degrees if the pixel is along a positive diagonal (22.5 to 67.5 degrees)
- 90 degrees if the pixel is along a vertical direction (67.5 to 112.5 degrees)
- 135 degrees if the pixel is along a negative diagonal (112.5 to 157.5 degrees)

Next step is to get a thin line (one pixel) of the border, this process is called non-maximum suppression and it changes all values that are not on the edge to zero, taking under consideration the direction set on the previous step.
If the line breaks up on a single point because the noise particularities of the image; this has to be fixed by the Hysteresis Process. This process puts two thresholds in order to evaluate if the pixel is above or below the thresholds and putting it into the right place.

2.1.6 Marr-Hildreth (Laplacian of Gaussian)

It is very common to use this tool in edge detection as it highlights the regions that have quick changes in an image (remember that intensity in pixels that are on the edge are higher than the ones which are close).
The functioning, starts with a smoothening of the original image and the Laplacian takes an image on grey scale to output another image in also grey scale. The Laplacian L (X, Y) is defined as follows:

$$L(X,Y) = \frac{\partial^2 I}{\partial X^2} + \frac{\partial^2 I}{\partial Y^2}$$

Where I (X, Y) is the intensity of the pixel in the image.

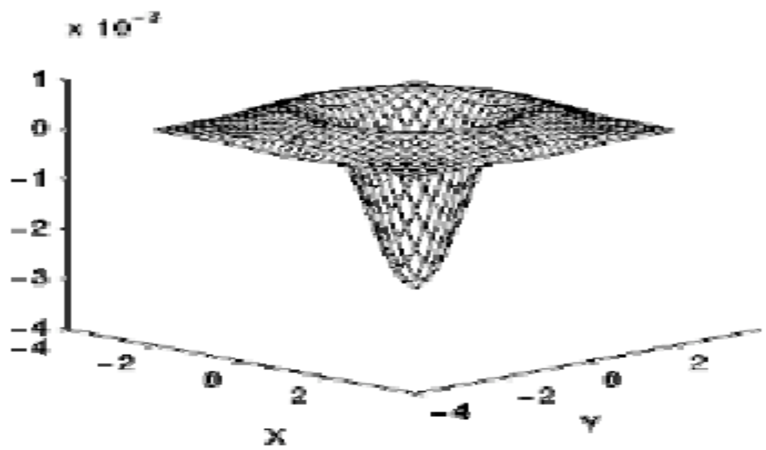
The reason why the image is smoothed before applying the Laplacian is because the two discrete Matrixes that are applied to the image are discrete and they are really sensitive to noise (as they are trying to approach the second derivative). These two matrixes are:

$$\begin{matrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{matrix} \qquad \begin{matrix} -1 & 2 & -1 \\ 2 & -4 & 2 \\ -1 & 2 & -1 \end{matrix}$$

But to make things simpler, as convolution operation is associative. We can convolve the Laplacian Filter with the smoothening filter in order to make only one convolution at the runtime execution. The Final Matrix would be like this:

$$\begin{matrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{matrix}$$

Which in 3-D is represented as a cone downside as we can see on the next figure:



2.2 Detection based on ASIFT method

Other approach while detecting objects is the one stated on [k] and that is the ASIFT method. ASIFT stands for *Affine Scale Invariant Feature Transform.* This method takes under consideration 6 features of the object, which are:

- Translation
- Rotation
- Change in scale (zoom)
- Latitude angle
- Altitude angle
- Transition tilt (inclination)

The method is trained by some previous images, which are the samples of the algorithm; these samples are taken in a variety of angles to make the algorithm more robust.
Then the algorithm takes all points from the image and compares them with the surrounding 9 points, if the point is not a potential point of the object that the algorithm is searching for, it is discarded. After a few iterations, the algorithm detects the shape of the object that we were trying to detect.
This method is an evolution of another method that is also based on SIFT.

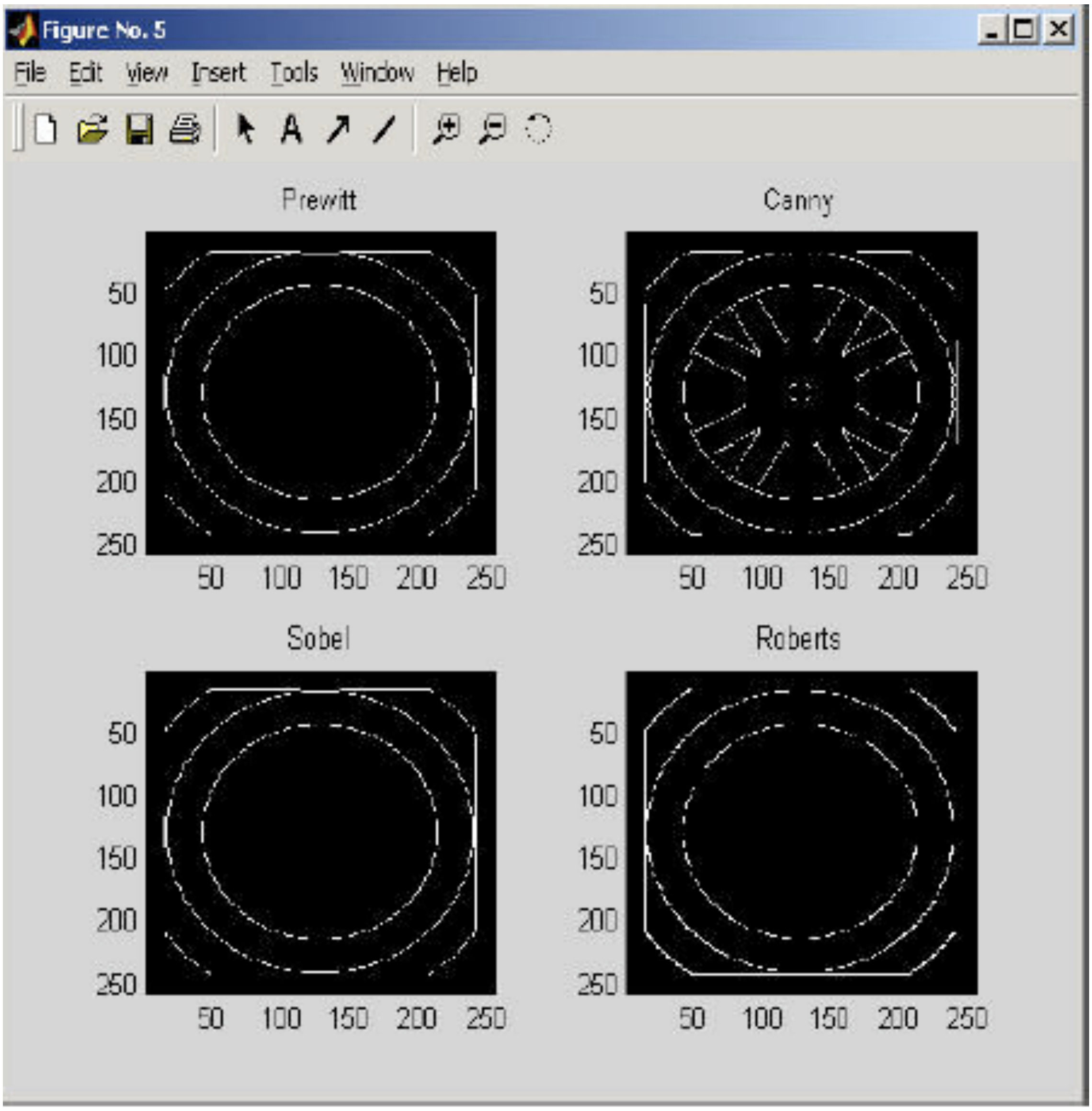
2.3 Comparison Between the different methods.

In this subchapter we will see differences between Methods based on the derivatives of the images and the ASIFT and ASIF method.

2.3.1 Comparison Between the different derivative based methods

As seen on [G], the researches have developed a program in Mathlab to show the edge detection for each of the algorithms, we can see that the input image on each of all the algorithms was:

Next picture shows edges detected on each out of four algorithms:



As we can see and as we said before, Canny algorithm holds the best results, as is the algorithm that takes the best of all the other algorithms, it is the only one that can detect the radius of the wheel. The other algorithms shown in the figure hold really similar results between them.

In the case of the leaves, we should use the canny algorithm as is going to detect the shapes of dents better than the other algorithms, as is going to hold on to better details, even though it is going to be slower than the other algorithms. In the case of the chromosomes we could use any other operator as the shape of the chromosome is much more rounded and it doesn't have many details.

2.3.2 Comparison Between SIFT and ASIFT method

The difference between them is whereas in ASIFT the number of parameters taken under consideration are 6, in SIFT the number of parameters taken under consideration are 4. In [k] they made a comparison of the two algorithms were the accuracy is made by inserting data into this formula:

$$ACCURACY\ RATE\ = 100 \times \frac{N_{to}}{N_{do}}$$

Where N_{to} is the number of pictures that have been used for training the algorithm and N_{do} is the number of detected objects on the dataset.

Object recognised	Detection Rate in SIFT method	Detection Rate in ASIFT method
Book	91.66%	95.83%
Monitor	87.5%	91.66%
Stapler	83.33%	91.66%

These statistics show that ASIFT method is better than the previous one (SIFT) while detecting an object.

2.3.3 Pros and cons about detection Methods

Algorithm	Pros	Cons
Robert's Operator	Really simple with only a few operations so it is not time and process consuming.	It only runs 45º on each direction so it is not too efficient. It is sensible to noise, as it doesn't filter the image.
Prewitt Operator	Really simple with only a few operations so it is not time and process consuming.	It runs on 90º on each direction but it doesn't filter the image so is sensible to noise.
Sobel Operator	The same as Prewitt Operator.	The same as Prewitt Operator.
Gabor (Gaussian)	It is efficient as it is based on the way humans find textures.	It is time consuming, as the operators have to convolve with other filters to make some "Gabor Spaces".
Canny (Gaussian)	It filters the noise at the first step and it has the non-maximum suppression in order to held a thin line at the end; If there is some mistake while doing it, Hysteresis process fix it within the two thresholds.	It has a lot of operations to be done so it is really time and process consuming.
Marr-Hilderth (LoG)	It smoothens the image as a first step so it becomes less sensitive to noise. It also highlights the regions that have quick changes in an image so it analyzes the surrounding pixels of the area.	It doesn't work really well on spaces that don't have surrounding pixels like corners or curves.
ASIFT	It is trained by several images on different points of view. It takes under account 9 of the surrounding points on the image.	It is time consuming as the algorithm has to be trained before.

3. MORE INFORMATION ABOUT TECHNOLOGIES USED IN RECOGNITION

There are three main steps of pattern recognition, these can be easily found in several papers such as [C], [D] or [E]. These steps are:

- Image preprocessing
- Learning
- Classification

Image preprocessing comes right after the image input. It makes the image to be settled for learning, so it considers steps such as changing pixel colors, changing to grey scale, changing size of image, etc.
The learning process receives the features from the first step and takes under consideration new manual knowledge as well as automatic knowledge.
Classification process gives an output based on marks of the database, taking under consideration the similarity with them.

These three steps are common in leaf and chromosome recognition even though its true that both recognitions have their own ways of doing it, as their features are not the exact same thing.
These ways of making recognition will be explained in the next chapter.

4. DETECTION AND RECOGNITION OF LEAVES AND CHROMOSOMES

In this chapter we will see different technologies employed on detection and recognition of specific methods used in leaf and chromosome detection.

4.1 LEAF DETECTION

When it comes to classifying leafs, the first step that has to be taken is the feature extraction, or in other words, leaf detection. According to [B] we can extract 14 leaf features based on the shape, dents and veins that the leaves have. These 16 features are:

- Shape: Slimness, roundness, solidity and moment invariants (there are 7 of them)
- Dent: Coarseness, size, angle and sharpness
- Vein: Ramification and camber.

This 16 features are not often used in the rest of the papers, as stated on [E], most of the papers use another 5 basic features that lead to another 12 features; these features were defined by Wu et al. (2007).
These five basic features are:

- Diameter
- Physiological length
- Physiological width
- Area
- Perimeter

From these five basic features we can develop 12 digital morphological features (smooth factor, aspect ratio, form factor, rectangularity, narrow factor, perimeter ratio of diameter, perimeter ratio of physiological length and physiological width, vein features and 5 more features extracted by the division of previous features).

The first step, on detection, is to preprocess the fixed image to eliminate noise and other non-useful things such as color.
In order to extract the features we will only get the leaf's outline in black and the rest will be white. This is made in order to stay only with the leaf's shape and extract the features mentioned above. Once you have done the leaf detection by extracting these features, it is time to pass onto pattern recognition.

4.2 LEAF RECOGNITION

To begin with pattern recognition, the first step is to do a process called PCA (Principal component Analysis), which converts the 12 features into a coordinate system with only 5 variables. For more details refer to [F], which will be the reference work for this section; as it takes under consideration the 5 most used morphological features and it's the most well explained paper.
By a mathematical approach, using PNN (Probabilistic Neural Networks), which has three layers (Input Layer, Radial Basis Layer and competitive layer) we can get an output vector which will be added to the new matrix in order to get better results, as it will train the program by adding more information. Training was done with 1800 different leaves that were common in Yangtze Delta, China, Corresponding to 32 species of different plants.
While testing the application with 10 different leaves of each 32 species, this is 320 total tests; the average accuracy is 90.312% and some plants have low accuracy due to the simplicity of the framework.
In paper [E], we can see other approaches to image processing while doing the feature extraction. Obviously, paper [B] doesn't count as it was like that because it has defined totally different features. We have chosen the method in [F] as they provide a source code and it is possible to test the application in different scenarios.

4.3 CHROMOSOME DETECTION

There are several methods for chromosome detection; in this section we will see two different approaches

Paper [J] uses a process called "Skeletonization" to reduce the metaphasis plate into thin lines to analyze the chromosome arms that are held in the plate. Even though the Skeletonization process reduces the metaphasis plate into lines that are one point thick, the process keeps correlation with the original image. To do so, the paper explains that they iterate several times a method called STRIP that, on each iteration, removes points that are lying on the edge, and they don't alter connectivity in between them.

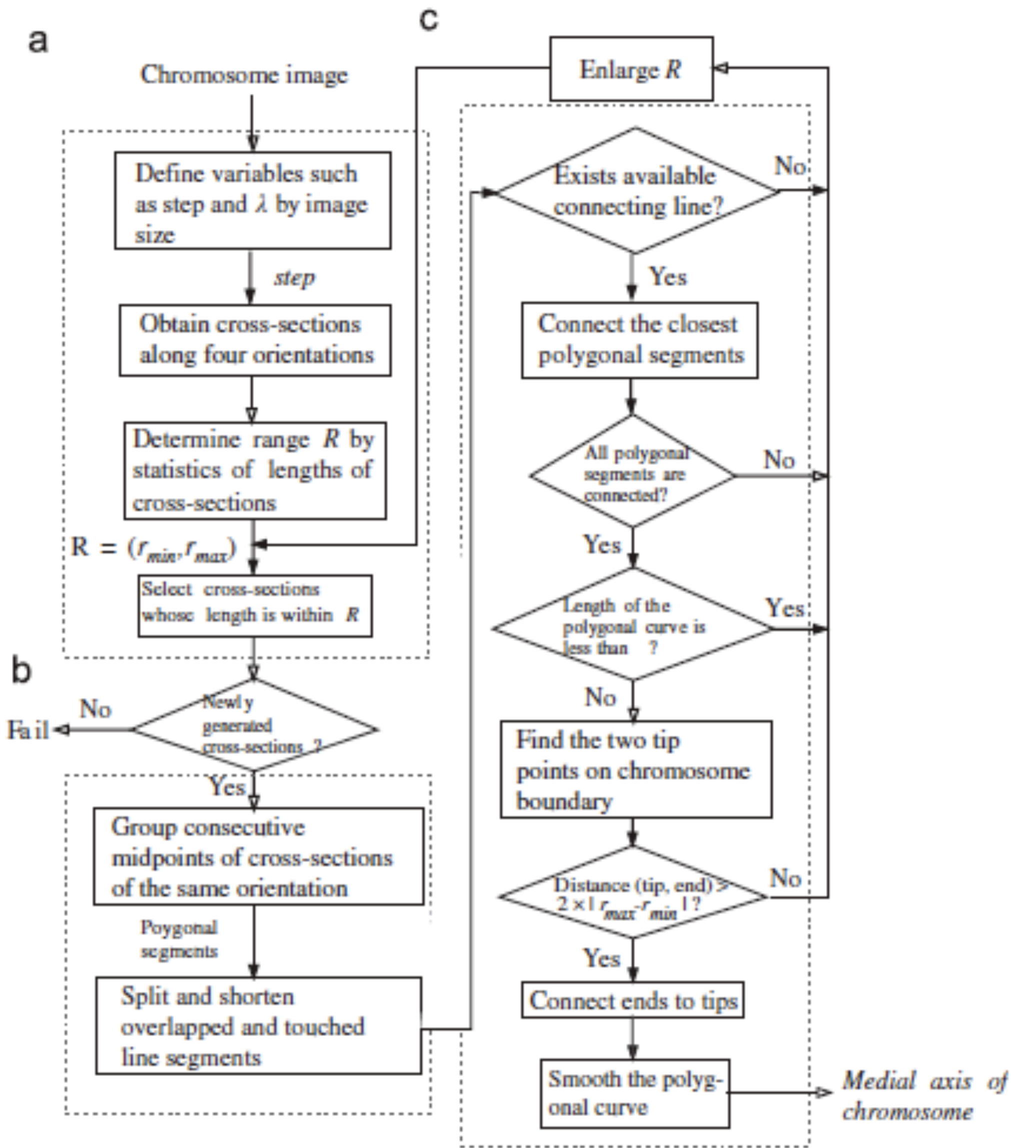
The other approach consists in extracting chromosomes according to their regions. A chromosome is divided into two regions (separated by the centromere into region P and region Q). While doing detection in chromosomes; it is difficult to determine which region corresponds to which chromosome, as the regions of one chromosome can overlap with other regions of other chromosomes. This is the most difficult challenge when it comes to applying Pattern Recognition into these kinds of applications.
Paper [D] gives a solution to this problem and divides each region of the chromosome into different subregions. After detecting all subregions, the aim is to classify all chromosomes into their groups (one out of 24 distinct chromosomes).
This approach takes under consideration a starting point (previously clicked on the screen) on a chromosome region and swipes angles to determine in which direction is the region going to be.

These two approaches are completely different, as the first one doesn't take under consideration the overlapping of the chromosomes; whereas the second approach does it.
The first approach would be suitable if we previously knew if the chromosomes are not going to be overlapped. The pros of this method are that no human operation is required as the Skeletonization process does it all automatically.
The second approach is more useful in terms that we don't have to worry about whether a chromosome is overlapped or not. On the other hand the cons of this method are that human work has to be done. This approach is suitable when we know that chromosomes are going to be overlapped and we need to separate all the metaphasis plate.

4.4 CHROMOSOME RECOGNITION

As we have already seen how chromosomes are detected, we will focus on how chromosomes are recognized from their Karyotype plate.

The approach to chromosome recognition once we have the karyotype plate is the one done by paper [I], which is based on local band patterns. This process doesn't take under account the chromosome's orientation or the bending of it, as it extracts the medial axis or the longitudinal axis. For this to happen, the paper shows an approach to extract the medial axis of the chromosome, which consists on three separate stages, which are defined, in the figure above (a, b and c)



After extracting the medial axis, the next aim is to extract the band profile (a sequence of gray-values sampled along the medial axis of a chromosome and can be intuitively treated as a time sequence of a specific length), which, thanks to similarities in them, the computer is able to recognize the chromosome and classify them.

5. FUTURE WORK

In this chapter we will see what we can do to improve or to make an evolution of these methods that we have seen on the previous chapters.

5.1 FUTURE WORK REFERED TO LEAF DETECTION AND RECOGNITION

As we have seen on the points 2 and 4.1 leaf detection is all about getting the shape of the leaf and getting several parameters (remember that based on two different authors, parameters would differ). But the thing that hasn't been done is to make a source code that combines the two of each. We mean to just have a source code that detects the leaf with an edge recognition algorithm (such as canny as it holds the best results) and once that has been done, the program calculates automatically all the parameters such as length, width, etc. We have seen that on paper [F] the source code automatically gets the leaf features, but you have to click on the beginning and the ending of the shape in order to calculate those parameters. If we make a source code that can automatically provide the beginning and the ending of the leaf to give it as a parameter to the source code on [F] by using the canny algorithm it would be much more quick to detect (which involves canny algorithm and extraction of features) and recognize (the source code made by paper [F]) leaves in an automatic way.

5.2 FUTURE WORK REFERED TO CHROMOSOME DETECTION AND RECOGNITION

About Detection, the Skeletonization process we saw on 4.3 is just another way to get edge detection on several chromosomes to divide the metaphasis plate and get individually all chromosomes lying in there. The Skeletonization algorithm has the problem that as it gets on more iterations, the information is being eliminated so the problem is that if, on the basis of the first iteration, the algorithm suppresses a point that is valuable the whole algorithm will go wrong. We cannot take that risk so we could use canny algorithm to take all the chromosomes lying on the metaphasis plate.
We could also use the approach made by [D] which divides the chromosome into subregions and detects all the chromosomes. Future work here would involve suppressing the step on which you have to click on the beginning and end of the chromosome to detect it.
Considering both approaches and after choosing the best way to solve this problem, further work would consist on giving the karyotype plate to the work stated on [I] to have an automatic way of recognizing chromosomes.

6. SUMMARY

With global warming, species are tending to extinguish. This is not an exception with plants and that is the reason to have a big database of them. As database would be huge human made database would be impossible, here is where pattern recognition comes. Computers need to recognize the kind of specie that is going to take input on the database. According to [B] even though we can use several features of the plant to recognize the specie such as leaf, flower, stem and fruit. Leaves of plants are easy to input in a computer as they can be scanned or photographed easily as they are planar. This is why leaf recognition is so important nowadays, and its still a big challenge.
As not only plants are in danger of extinguishing we also have to have a database for other species. Chromosomes are the easiest way to classify other species so that's the reason why Chromosome recognition is so important. The main problem with chromosome recognition is that chromosome regions are mixed so it is really difficult to determine to which chromosome corresponds the region that is being analyzed. We already have discussed several approaches to this challenge in the paper.

7. REFERENCES

[A] Jayanta Kumar Basu, Debnath Bhattacharyya, Tai-hoon Kim. "Use of Artificial Neural Network in Pattern Recognition." International Journal of Software Engineering and Its Applications. Vol. 4, No. 2, April 2010.
[B] Qingfeng Wu, Changle Zhou, Chaonan Wang. "Feature Extraction and Automatic Recognition of Plant Leaf Using Artificial Neural Network." Institute of Artificial Intelligence, Computer Science Department, Xiamen University.
[C] Yas Abbas Alsultanny, Musbah M. Agel. "Pattern Recognition Using Multilayer Neural-Genetic Algorithm." Computer Science Department College of Computer and Information Technology, Applied Science University. May 2002.
[D] Toru Abe, Chiecko Hamada, Tetsuo Kinoshita. "Chromosome Image Recognition with Local Band Patterns." MVA2009 IAPR Conference on Machine Vision Applications, May 20-22, 2009, Yokohama, JAPAN
[E] Mohamad Faizal Ab Jabal, Suhardi Hamid, Salehuddin Shuib, Illiasaak Ahmad. "Leaf Features Extraction and Recognition Approaches to Classify Plants." Faculty of Computer Science and Mathematics, Universiti Teknologi MARA, August 2013
[F] Stephen Gang Wu, Forrest Sheng Bao, Eric You Xu, Yu-Xuan Wang, Yi-Fan Chang, Qiao-Liang Xiang. "A Leaf Recognition Algorithm for Plant Classification using Probabilistic Neural Network". July 2007.
[G] Raman Maini, Dr. Himanshu Aggarwal. "Study and Comparison of Various Image Edge Detection Techniques". International Journal of Image Processing (IJIP), Volume (3) : Issue (1)
[H] G.T. Shrivakshan, Dr.C. Chandrasekar. "A Comparison of various Edge Detection Techniques used in Image Processing". IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, September 2012.
[I] Jau-hong Kao, Jen-hui Chuang, TsaipeiWang. "Chromosome Classification based on the band profile similarity along approximate medial axis". 2007 Pattern Recognition Society. Published by Elsevier Ltd.
[J] Judith Hilditch, Denis Rutovitz. "Chromosome recognition". Cytogenetics Clinical and Population Research Unit, United Kingdom Medical Research Council
[k] Reza Oji. "AN AUTOMATIC ALGORITHM FOR OBJECT RECOGNITION AND DETECTION BASED ON ASIFT KEYPOINTS". Signal & Image Processing : An International Journal (SIPIJ) Vol.3, No.5, October 2012