Digital image processing

Vision is the most dynamic of all our senses since it provides us with a huge amount of information about what surrounds us. It is not surprising that an ancient Chinese proverb that quotes: “ A picture is worth a thousand words” is still widely used. All this information is valuable for simple procedures (for example planning our everyday activities), but also for more complex processes as the development of our intelligence. At the level of social organization, images are also important as a means of transmitting information, and almost all of today’s media are based on our vision. The huge amount of visual information and the need for its processing, lead scientists and technicians towards research in order to discover a means for digital image storage and processing using computers. This effort resulted in a new Information Engineering Industry called “ Digital Image Processing and Analysis”. This industry began to grow fifteen years ago. However, it has shown a dynamic development, especially during the most recent years and it is considered a science and technology with a promising future and many potential. As the title indicates, Digital Image Processing is concentrated on digital images and their processing by a computer. Therefore, both the input and output of this process are digital images. Digital image processing can be used for various reasons: improvement of the quality of images, filtering of noise caused by transmission, compression of image information, image storage and digital transmission. On the other hand, digital image analysis deals with the description and recognition of the content of an image. This description is usually symbolic. Therefore, the input when it comes to digital image analysis, is a digital image and the output is a symbolic description. Image analysis principally tries to mimic human vision. Therefore, an identical term which is often used is “ Computer Vision”. It has to be

underlined that computer vision is a complex neuro-physiological mechanism driven by upper level knowledge (high level vision). The characteristics of this mechanism are not known and existing mathematical models are yet inadequately accurate. As a result, it is difficult to simulate high level vision by a computer. For this reason, the methods used for image analysis when it comes to machine vision and human vision vary significantly. Image analysis is easier in the case of applications where the environment, objects and lighting conditions are fixed. This is usually the case of a production process in industry. The branch of computer vision which is used in industry is called " Robotic Vision". The analysis is much more difficult in applications where the environment is unknown and there is a large number of objects or the different objects are unclear or difficult to separate (for example in biomedical applications or in outdoor / natural scenes). In such applications, even experts find it difficult to recognize objects. For these reasons, it is still difficult to obtain a general image analysis system. Most existing systems are designed for specialized applications.

OTHER RELATED RESEARCH AREAS

Digital image processing and analysis are related to various other scientific areas because of their subject of research. Recently, there is a tendency, at least in terms of applications, for digital image processing to become an interdisciplinary industry. Some related research areas are:

- Digital Signal Processing
- Graphics
- Pattern Recognition
- Artificial Intelligence

- Telecommunications and Media
- Multimedia Systems

We will examine the relation of each of these areas with digital image processing and image analysis independently, since the way they are related is not very clear.

Digital Image Processing Vs Digital Signal Processing

Every image can be described as a two-dimensional signal. Therefore, for the analysis and processing of digital images all the techniques of digital signal processing can be used. This area provides the theoretical and programming base for image processing.

Digital Image Processing Vs Graphic

Fundamentally, the subject of graphic is digital synthesis. Therefore, the input is a symbolic description and the output is a digital image. For this purpose a geometric modelling of the display object takes place, as well as a digital description of the lighting conditions and digital production of the objects' illuminants in the assumed position of the camera.

Digital Image Processing Vs Pattern Recognition

Pattern recognition deals with the classification of an object to a class of models (class pattern). For example, trying to recognize whether a new object is a resistor, a capacitor, or an integrated circuit. For this purpose, an object has to be described using certain characteristics (features), mostly numbers (for example: diameter and area), and then it can be classified based on these characteristics.

Digital Image Processing Vs Artificial Intelligence

Artificial intelligence and image understanding are areas where a symbolic representation of an image is converted to another more complex representation or a representation more easily comprehensible to humans. Usually, techniques for representation of human knowledge (knowledge representation) and reasoning (inference) are used for this purpose. The analysis of a " scene" requires higher cognitive processes and that is why it is also known as high-level vision. On the other hand, image processing is more related to the lower levels of vision, that take place in the human eye and optic nerve and as a result it is also known as low level vision.

Digital Image Processing Vs Telecommunications

The field of telecommunications is related to digital image transmission in telecommunication networks that transmit voice and data. The resulting networks are called Integrated Services Digital Networks (ISDN). A key problem concerning image transmissions is the compression of the images' content, since a colour image requires about 750 Kbytes for its description. The construction of special algorithms for coding and decoding is also required. Digital image processing is also directly connected to the HDTV (High Definition TV). Its basic aim is the compression of the vast amount of information and the improvement of the quality of images that are received.

Digital Image Processing Vs New Generation Databases

The new generation of databases includes image, signal (voice) and data storage. In this field, digital image processing deals with image coding and analysis by finding smart ways of recovery (retrieval) of images.

DIFFERENT AREAS OF DIGITAL IMAGE PROCESSING

Digital image processing includes several areas that are closely related.

Some of those areas are mentioned below:

- Capture of the image
- Digital Filtering of the image
- Edge Detection
- Region Segmentation
- Shape Description
- Texture Analysis
- Motion Analysis
- Stereoscopy

It is logical that the description of all these areas is not possible in a short presentation. However, the literature is so wide that several books would be needed in order to describe adequately the digital image processing. Moreover, image processing is a cognitive area that makes extensive use of specialized mathematical, which makes it difficult to be presented to an audience. For this reason the description of the area it is purely qualitative.

Capture of the Image

The first thing that has to be described is the capturing mechanism of the images. The most classic means of capturing an image is by a photographic camera and a film. However, this technique is not very useful in the field of digital image processing, since the captured image cannot be easily processed by computer. On the other hand, electronic capture is particularly interesting because the image can be digitized and then processed by a computer. For this reason, conventional electronic video cameras are widely

used. Electronic video cameras scan the image and produce an electrical signal as an output. There are various camera technologies (for example Orthicon, Vidicon, CCD). The electric signal produced by the camera is then led to a frame grabber. During the process of digitalization, the analogue signal is converted to a digital signal using an A / D converter. Thus, the image is converted into a matrix of 256×256 or 512×512 points (spots). Each point is typically represented by 8 bits, i. e. 256 levels of brightness. However, a common technique in some fields (e. g. robotics) is a binary representation of images that uses only 1 bit / position. This representation is used in order to save memory and speed in the case of simple applications. In some other cases where the colour of an image is critical, colour cameras and three A / D converters are used. In this case the three primary RGB colours (red-green-blue) are saved with 3×8 bits / position. As a result, digital image processing has large memory requirements, even for black and white images. The digitized image is stored as a file on the computer’s local disk. To be able to see the image, we need to transfer it to a special RAM memory (image memory) connected to a monitor. Such monitors may be black and white or colour (RGB). Colour monitors are mostly used even in black and white applications because they have the ability to show “ pseudocolours”. Finally, the image in any program of image processing appears as a two-dimensional table (array) 256×256 or 512×512 which is “ filled” by the computer’s local disk or by the image memory in which the image is stored.

The process of capturing an image can cause the following distortions:

- Blurring

- Noise
- Geometric Distortions

Therefore, before any application the correction of these distortions is essential. Geometric corrections are mostly needed where geometric information is important, e. g. stereoscopes, topography. The reduction of blurring is done through the process of recovery (restoration). The recovery process is particularly important in applications where there is movement, (e. g. a ‘ scene’ of a road) because the motion introduces blurring. In most cases the filtering of the image is also very important in order to remove noise. This can be done by various linear or nonlinear filters. Usually, nonlinear filters are mostly used because they maintain the contrast of the edges, which is a very important factor for human vision. The overall image contrast can also be improved by special non-linear techniques (contrast enhancement).

Edge Detection

Another important process of image analysis is the recognition (tracing) of contours. There are many techniques that can be used for edge detection. The development of various edge detection techniques was imperative due to the important information about the objects used for identification, which can be found in the contours. The dual problem of edge recognition is the recognition of regions in an image. This problem is called image segmentation. Usually the different regions of an image are coloured with “ pseudocolours”.

Texture Analysis

In several industrial applications the recognition (or analysis) of the texture is very important. An example of the importance of texture recognition in industrial applications is its use in recognition of different fabrics, or recognition of flaws in a cloth.

Recognition of traffic is also a very important field of computer vision for many applications, e. g. traffic monitoring, automatic driving, recognition of moving objects, digital television, videoconferencing, telephone with image compression and broadcast animation. Is should be noticed, that recognition of traffic has large memory requirements for storage and real time processing. This can only be achieved through parallel image processing and use of special VLSI chips.

Shape Description

Another area of computer vision which is particularly useful in pattern recognition is the description of shape (shape representation). A shape is described either by its border, or by the area it covers. The edge of a shape can be described in different ways, e. g. Fourier descriptors, splines. The area of a shape can be described by methods of mathematical morphology, decomposition with simple shapes, etc. These methods are used either for the storage of a shape, or for its identification.

Stereoscopes

Many applications require measurement of depth. In this case stereoscopy with two cameras can be used. Stereoscopy is particularly useful in photogrammetry and robot movement in a three dimensional space.