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# Report


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## Digital Imaging

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# Main principles:

Mathematical morphology of mathematics and language used is set theory, so it has a complete mathematical foundation, which is for morphology analysis and processing, morphological filter characteristics and system design. The application of mathematical morphology simplifies the image data, preserves their basic shape properties, and removes irrelevant structures. Mathematical morphology algorithms have a natural parallel implementation of the structure, to achieve the morphological analysis and processing algorithms in parallel, greatly improving the speed of image analysis and processing.
Mathematical morphology consists of a set of morphological algebraic operators that have four basic operations: expansion, erosion, opening and closing.

Based on these basic operations, we can derive and combine various mathematical morphological practical algorithms, which can be used to analyze and process the image shape and structure, including image segmentation, feature extraction, edge detection, image filtering, image enhancement and restoration. Mathematical Morphology uses a "probe" called a structural element to collect the information of the image. When the probe is constantly moving in the image, the relationship between the various parts of the image can be examined to understand the structural features of the image.

# Three selected algorithms:

## Top Hat

Top Hat algorithm is the result of the original image minus the result of opening of the image. The mathematical expression is as follows:

$$\mathtt{dst} = \mathrm{tophat}(\mathtt{src}, \mathtt{element}) = \mathtt{src} - \mathrm{open}(\mathtt{src}, \mathtt{element})$$

Because the result of the open operation is an area where the cracks or local low

intensities are enlarged, subtracting the open image from the original image gives a render that highlights a brighter area than the area around the original image outline. Top hat algorithm is often used to separate the lighter spots than nearby ones. When an image has a large background, and small items are more regularly, this algorithm can be used for background extraction.

## Black Hat

Black Hat algorithm is the result of the original image minus the result of closing of the image. The mathematical expression is as follows:

$$\texttt{dst} = \text{blackhat}(\texttt{src}, \texttt{element}) = \text{close}(\texttt{src}, \texttt{element}) - \texttt{src}$$

The effect after the black hat operation highlights the darker area than the area around the original outline. Therefore, black-hat is used to separate darker patches than nearby dots.

## Morphological Gradient

Morphological Gradient is the result of the subtraction of the expansion and corrosion diagrams. The mathematical expression is as follows:

$$\texttt{dst} = \text{morph\_grad}(\texttt{src}, \texttt{element}) = \text{dilate}(\texttt{src}, \texttt{element}) - \text{erode}(\texttt{src}, \texttt{element})$$

This operation can highlight the edges of blobs. We can use morphological gradients to preserve the edge contour of an object.

# Three selected applications:

## Vehicle license plate identification system

The application consists of two main modules: license plate region's rough detection and license plate exactly location. The former characterized by vertical gradients detection extracts candidate regions from an input image, while the latter conceptualized in terms of mathematical morphology aims to locate the license plate fast and accurately.

## Fingerprints detection

In fingerprint detection, use the mathematical morphology to remove the superfluous information for genuine feature extraction and measure the feature extraction performance through sensitivity and specificity.

## Medical images edge detection

Medical images edge detection is an important work for object recognition of the human organs and it is an important pre-processing step in medical image segmentation and 3D reconstruction. Conventionally, edge is detected according to some early brought forward algorithms such as gradient-based algorithm and template-based algorithm, but they are not so good for noise medical image edge detection. A novel mathematical morphological edge detection algorithm is proposed to detect the edge of lungs CT image with salt-and-pepper noise.

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