〈**Systems**〉

Object Detection Technologies for Image Application Products

Image processing, Object detection, Model-based matching, Image features, Time correlation

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Abstract

With the recent evolution of computer performance and its prices declining, image analysis technologies have been largely adopted in industrial fields. For many years, we worked on the development of image analysis technologies and released image-application products. Image analysis technologies are defined as the techniques for the image processing to input image data such as "extraction of contour lines," "separation of bright portions and dark portions," "extracting a brightness changing direction," etc. Further, this is a technique to extract the necessary information by analyzing the image processing data. Among image analysis technologies, the object detection technique is a very important one as its application range is very wide. We have developed an object detection technology to detect an object from the input image based on shape and pattern, and on the temporal changes of part of the subject image. We applied this technology to our image application products.

1. Preface

With recent progress of computer performance and declining prices, image analysis technologies have been largely adopted in industrial fields. For many years, we worked on the development of image analysis technologies and developed and released various image application products such as bin picking systems[(1)], overhead catenary inspection systems[(2)], and intruder detection systems[(3)].

The bin picking system detects an object from a container bin which photographed with a camera, defines a location of an object, and picks up the detected object using a robot arm.

The Overhead Catenary Inspection (OCI) system checks the status of overhead catenary from which electric power is fed to electric cars, using images from the camera that is installed on the roof of a train.

The intruder detection system analyzes images of a surveillance camera for the automatic detection of the intruding object, such as a person or a vehicle.

This paper introduces our object detection technology which is the most important one among image analysis technologies that supports our various image application products.

2. Object Detection Technology

Image analysis technologies are defined as the techniques for image processing that input image data such as "extraction of contour lines," "separation of bright portions and dark portions," and "extracting a brightness changing direction," as well as others. This is a technique to extract the necessary information by analyzing the image processing data. Fig. 1 shows the outline of our image analysis technologies. The object detection technology has wide application potential and is a very important technology.

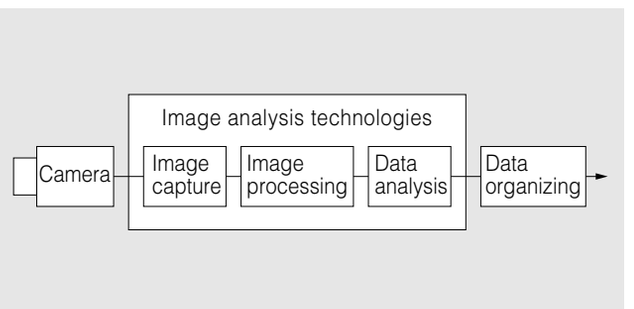

Fig. 1 Outline of Image Analysis Technologies
Image analysis technologies are used to extract necessary information by analyzing the image processed data from the raw image.

In the category of object detection technology, the task of finding a given known object is generally called "the specific object recognition technique." In other words, this is a technique to find a given known subject (parts, seal, structure, etc.) in an image by the process of judging the presence of a given subject in the image and finding the exact location in the image. The early level of known object recognition technique in this industry's history was the simple task of finding a hole which appeared as dark one. With the progress of computer performance, new recognition methods were developed such as an image matching method, or method to extract a line segment and circular arc from an image and match it with an example image. Recently, it became possible to detect more complicated known objects by matching the example image based on multi-dimensional arithmetic vector data of an image.

Other than the above, there is another technique to detect the unknown subject entering into the frame of an image. In this kind of object detection technique, it uses the normal condition of an image as a reference image and stores it in the data log and detects the changing object from the reference image as a foreign object. Recently, new research is under way to categorize the specific part of an image of a foreign subject like a man, dog, cat, etc.

3. Shape-Based Object Detection

As a shape-based object detection method, there is an example model-based matching method. For the task of finding a given, shape-based data like a counter line or a circular arc, is chosen from the reference images photographed in advance, and produces an example shape model of the object in the image. In case of detecting a given object, the system extracts the similar shape object data in the input image and matches such data with the example shape model object. Fig. 2 shows an outline of the model-based matching method processing. Since collation is performed according to the determined shape of an object, this method is full proof against external turbulence such as variations in brightness or contamination on the surface of the object. Basically, this method cannot respond to the appearance change in object size in the images. Our experiment suggests that we could detect the object so long as the change level is around 10%. Fig. 3 shows an example of a cast part of an object detected from the image.

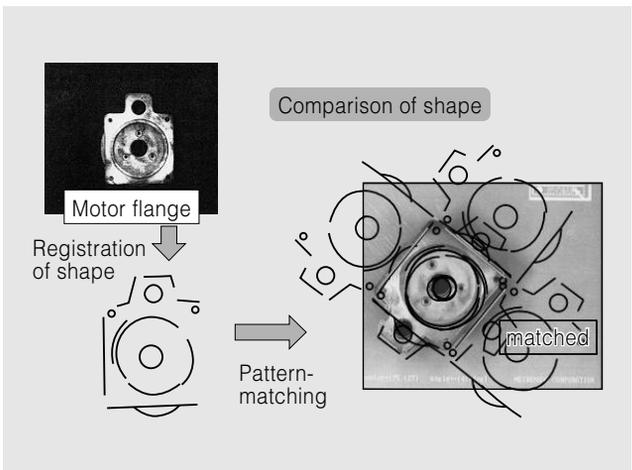

Fig. 2 Outline of Model-Based Matching Method Processing

The model-based matching method is used to detect a required object by pattern-matching with pre-defined shape data and the shape data extracted from input image.

Fig. 3 Example of Cast Part Objected Detected from Image

A cast item was detected on the basis of the object shape in image.

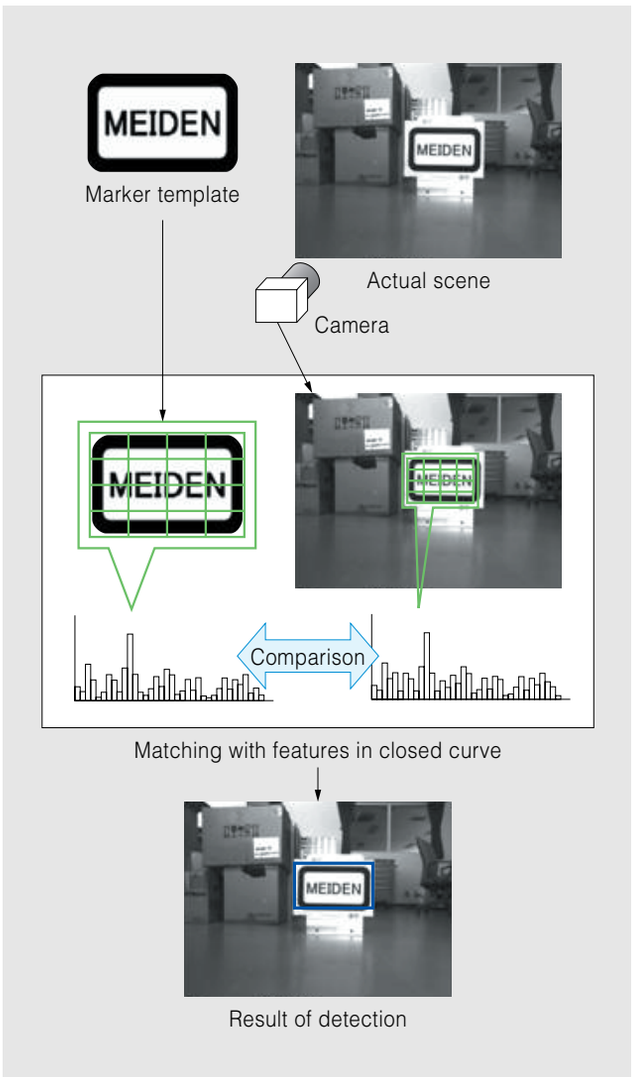

Fig. 4 Outline of Object Detection Using Features in a Closed Curve

Features in a closed curve provide information about position and size of the closed curve. This information also involves the direction of rotation obtained from a pattern enclosed in the closed curve and a multi-dimensional vector of the digitized pattern.

4. Object Detection Based on Patterns

We recognize that most items to be used as markers are surrounded by a certain frame. As a method of marker detection using a closed curve, we developed an approach to use features in a closed curve[4]. The feature in a closed curve mean image provides information about the position and size of the closed curve by extracting the closed curve from an image with multi-dimensioned vector data of digitized patterns, and the rotational direction is obtained from the patterns in the closed curve. Fig. 4 shows the outline of object detection using features in a closed curve. The matching of a feature in a closed curve is performed by matching a multi-dimensional vector showing a pattern in the closed curve. The multi-dimensional vector has a normalized value based on overall brightness. Accordingly, if features in a closed curve are used, it is possible to perform object detection despite changes in object size, rotation, and brightness. Figs. 5 and 6 show examples of marker detection using features in a closed curve.

5. Object Detection Based on Time Series Variation

For temporal changing images, a pattern of time series changes in the correlation value of these images is called "time correlation." There is a proposal to use time correlation for the identification of image status[5]. Extending this idea, we proposed an improved method by taking an input image from a surveillance camera and dividing it into small square shaped regions in a grid pattern and using the correlation value between a partial image in each small region. Its corresponding background image is repeatedly computed at predetermined time intervals against the sampling input image. Based on pattern changes over time in correlation ratios obtained from the recorded changes, we proposed a method to determine the presence, or absence, of any changes per each small region[6]. When this approach is adopted, it is possible to detect the presence or absence of any unknown object in each part of the image. Figs. 7 and 8 show examples of

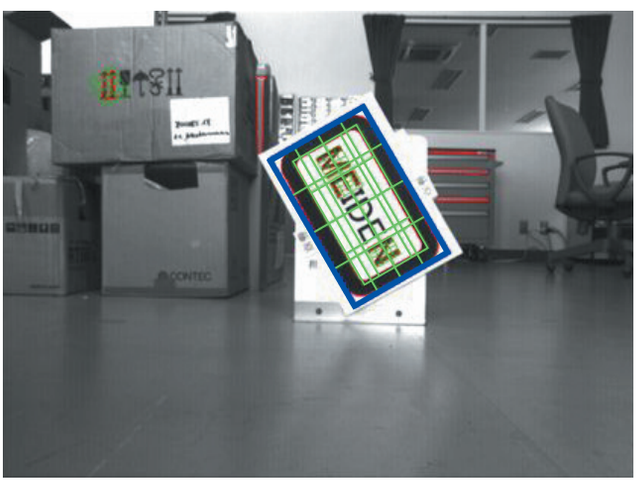

Fig. 5 Marker Detection Using Features in Closed Curve, Example 1
A marker with changes in rotation is detected.

Fig. 6 Marker Detection Using Features in Closed Curve, Example 2
A marker in a distant and dark place is detected.

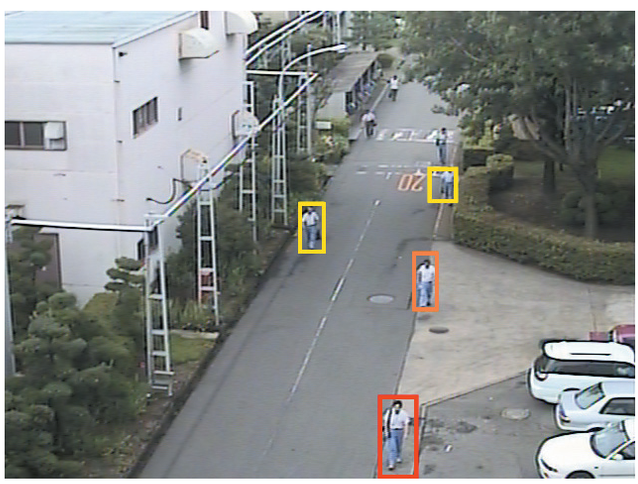

Fig. 7 Example of Passers-by Detection
Passers-by are detected.

Fig. 8 Example of Detection of a Suspicious Person in a Night Public Square
A suspicious person in a public square at night is detected.

person detection based on time series changes in images.

6. Postscript

For many years, we worked on the development of image analysis technology and released image application products. This paper introduced our object detection technologies which are especially important among image analysis techniques as it supports our image application products. With the evolution of computer performance and lowering prices, image analysis techniques are widely used in industrial fields. We expect more applications of image analysis techniques in our products in the future. Moving forward, we will make every effort to develop new image analysis techniques and would like to contribute to commercialize the image application products that will help society.

《References》

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