An Investigation and Application of High-Speed Measurement and Precise Control Based on Machine Vision

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Abstract — Machine vision inspection is a new detection technology based on computer vision and image processing. It obtains a variety of parameters of work piece’s that can be described by image processing, and gets the parameters understood and judged. It can be applied to the actual testing, measurement and control at the end. It has the features of Non-contact, high accuracy, wide application range and high degree of automation and so on. As machine vision online testing equipment installed in the production line, which detects speed must keep high degree of synchronization with the high-speed production line. The key technology to achieve its high-speed synchronous is precise control of camera and high-speed detection of image.

Keywords - Machine vision; Target detecting; Image positioning; Precise control

I. INTRODUCTION

IOT (Internet of Things, IOT) is the development trend of the future of information and communication technology, as well as national strategies an important part of the layout.

Three typical characteristics of things can be summarized as overall perception, reliable transmission, intelligent processing, networking, object having addressable, can communicate, you can control features. Intelligent Transportation (Intelligent Transportation Systems, ITS) that is reflected in things in the transport sector, with huge economic and social benefits [1].

So the study of machine vision online detection on precision control of high-speed camera and high-detection of image, developing smart online testing equipment with independent intellectual property rights, and the urgent need to promote the high-speed visual inspection of theoretical exploration and innovation, to meet the current domestic market of intelligent manufacturing. It has great significance.

Meanwhile, the manufacturing sector needs to have the appropriate testing technology to ensure the production of quality products. As China has become the world's manufacturing base, the detection of the needs and requirements are also gradually increase. Machine vision is the recent development of a new technology; it is the use of means of electromechanical integration of the machine with the visual function. The introduction of machine vision detection field can be achieved in many cases high-speed line precision measurements.

With the highway intelligent transportation system continues to improve, to speed system, information technology, integration, flexibility and put forward higher requirements. Currently, machine vision through the erection of speed cameras in highway gantry lane highway vehicle image acquisition and image analysis measurement with the vehicle speed, speed research in the field has become popular. Visual gun having large amount of information, "seeing is believing", to facilitate modular, integrated, information technology, good flexibility and other advantages to meet the requirements of the development of intelligent transportation systems, and has broad application prospects [2].

In recent years, with the transfer of global manufacturing center to China, China has become, after North America, Europe and Japan, the world's fourth largest manufacturing market. China's manufacturing industry is facing a rare opportunity for the development of globalization. Historical development of manufacturing technology and manufacturing proved breakthroughs in key technologies often lead to significant advances in manufacturing technology and manufacturing industries. However, the high-speed line intelligent detection technology based on machine vision has been a bottleneck restricting the development of manufacturing industry is in urgent need of intelligent manufacturing key technology breakthrough. Due to the development and promotion of microprocessor speed in recent year’s high-speed industrial cameras, high-speed line detection techniques based on machine vision has become a hot research [3].

Machine vision inspection technology uses non-contact vision sensors through access to quality products, the appearance of the image to judge the product. According to the different stages of processing, appearance reflected the flaws of performance and quality of the product will cause different effects, divided into two main areas: 1) the appearance quality of the product as a product value of attachment, such as product packaging, printed appearance inherent flaws affect product quality perfect embodiment; surface defects 2) products directly affect the use of the product or further processing, deep processing of the user or client will bring great losses.

From the viewpoint of production cost savings, quality management product line high-speed detection can reduce raw material consumption, reduce labor costs. Therefore, for detecting the presence of artificial surface quality defects, the urgent need for an online intelligent automatic detection

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system. Machine vision technology has the detection speed, high accuracy, objective and reliable test results characteristics, with a suitable detection algorithm can quickly and accurately detect the product surface defects is one of the most promising Intelligent Manufacturing detection methods [4].

II. BASIC CONCEPTS

Target Detection: Lane highway in the scene, the vehicle from entering the scene to leave the scene of this process, we should target vehicle speed determination, we must first identify these moving targets, identifying those goals include target detection and target tracking, goals detection monitoring task is to detect the target scene all against the background of an instantaneous displacement, and determine its position in the two-dimensional image to provide reliable input feature for subsequent tracking.

Moving Target Detection: From the point of view of image segmentation, moving object detection that is, the video image of the temporal and spatial segmentation. Specifically, the video sequence that is chronologically arranged them on its axis, for different times, in different scenes appear in the foreground, because when there is the target appears, i.e. foreground moving object, always movement.

This fixed scene in a vehicle to detect moving objects, that is, on the time axis for each time the spatial domain image segmentation. Plainly speaking, that is, when the vehicle enters the visual inspection area, through arithmetic means, this movement of the vehicle captured, and the image segmentation that is to capture the target vehicle extracted from the background. Currently, neural networks and image processing are commonly used moving target detection methods.

Motion detection method based on image frame difference: interface difference method is based on the moving image; the adjacent or separated by a small picture frame has a strong correlation between the motion detection method proposed. Image sequence for continuous acquisition of images of adjacent frames or separated by a fixed frame, using the corresponding pixel with respect to time way to extract the movement area.

We suppose the two sequences of image that acquired at the time of t1 and t2: f(x, y, t1) and f(x, y, t2) This sequence with respect to time is the difference its operations as formula 1:

\[ f_\Delta(x, y) = |f(x, y, t_1) - f(x, y, t_2)| \]  

The result of the formula thresholding processing, segmentation threshold is set Td, then:

\[ F_{out}(x, y) = \left\{ \begin{array}{ll} 1 & \text{if } f_\Delta(x, y) \geq T_d \\ 0 & \text{otherwise} \end{array} \right. \]  

Td is segmentation threshold, can be given in advance or obtained by adaptive depending on the scene.

Motion detection based on optical flow field: in three-dimensional space, the motion can be used to describe the stadium, and when the three-dimensional model through the perspective projection into a two-dimensional image, moving objects often through a sequence of images of different brightness distribution to reflect, and therefore space in the stadium, says the image is transferred to the optical flow field (Optical Flow Field), optical flow field it reflects changes in the brightness of each point on the image trend, can be used as a real playground instantaneous velocity field approximated [5].

\[ f(x, y, t) \] gray-scale image of the temporal and spatial distribution, which is the image point (x, y) of the gray value in formula 3.

\[ f(x, y, t) = f(x + dx, y + dy, t + dt) \]  

Use Taylor to expand the formula 3, and take dt-> 0, ignore higher order terms, then:

\[ \frac{\partial f}{\partial x} dx + \frac{\partial f}{\partial y} dy + \frac{\partial f}{\partial t} dt = 0 \]  

Making \( u = \frac{dx}{dt}, v = \frac{dy}{dt} \) denote the pixel position at time t, the point (x, y) of two velocity components in the x and y directions, that is, the unknown quantity. The formula can be written as formula 5:

\[ \frac{\partial f}{\partial t} = \frac{\partial f}{\partial x} u + \frac{\partial f}{\partial y} v = \text{div}(U) \]  

Or:

\[ f_t u + f_y v + f = 0 \]  

Where \( \text{div} = (f_x, f_y) \) represents spatial and shades of gray of image. U = (u, v) represents the optical flow of a point, which is the optical flow field. \( f_x, f_y, f_t \) can be obtained by discrete difference. Obviously there is no optical flow constraint equation is a morbid equation must be made to the joint solving constraints.

Motion detection method based on background difference: Background subtraction method is suitable for the scene background fixed occasions, is now a way to split up the subject with the movement, it can be adapted slowly changing natural scenes. It is through the current frame image and the background image has been acquired directly subtracting the target area and then determining the motion segmentation by morphological operation threshold. Suppose f(x, y, t) for the current frame image, B(x, y) as a background image has been obtained, the test results as follows formula 7:

\[ F_{out} = |f(x, y, t) - B(x, y) > T_{min} | \]  

Where \( T_{min} \) represents mixed threshold. Depending on the scene can be attached area, location, etc. threshold as the constraint.

B(x, y) is the easiest way to get a moving target no empty background image as the background, but the actual movement of the target is not due to appear regularly in the field of vision, an empty background image is not always possible to obtain [7].

Adaptive background modeling and update: Background The purpose of modeling is to obtain ideal background image scenes to prepare for target detection, detection effect
depends on the merits background extraction effect, background extraction in turn depends on the background of the model used. Under normal circumstances, in the natural environment, many colors of objects are presented monomial or modal distribution characteristics, such as swing leaves, light reflection, rendering this feature more natural scenery.

III. EFFECTIVE RESOLUTION OF MACHINE VISION INSPECTION SYSTEM

Effective resolution is the resolution of the entire system, is an important indicator of the evaluation of the measurement system. By improving the effective resolution of the system will be able to improve the accuracy of the system. Improve the accuracy of machine vision inspection systems can start from effective resolution improve the system.

Machine vision inspection system consists of hardware and software components; hardware generally consists of a light source part, the lens portion, an image sensor portion and AD / conversion parts. Software typically includes edge detection, edge connectors, feature point positioning. These parts of the system have an impact effective resolution. Improve the system effective resolution method can also be divided into two categories, one is by improving the optical imaging system, and one is by improving mathematical modeling and image processing algorithms. A well-designed machine vision inspection system needs to consider these methods to obtain the appropriate effective resolution, as shown in Figure 1.

Begin increasing the effective resolution from optical imaging systems are often expensive, such as the price of the image sensor on the resolution with the increase exponentially increased. If you can locate on the characteristics of the target image in the sub-pixel level, the equivalent of increasing the effective resolution of the measurement system.

Table 1. Machine vision inspection systems effective resolution of evaluation data table

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Although scholars at home and abroad in recent years has made some progress on detection algorithm based on machine vision, but the overall research on high-speed detection system is still lack of theoretical support, so theoretical study of the structure of high-speed detection systems and high-speed precision control and related theory study on visual identification is an urgent need for current high-speed visual inspection.

High-speed line machine vision inspection implementation requires cooperating hardware and software algorithms visual system, both indispensable, only high-performance hardware system, no fast image processing algorithms, can not achieve the high-speed line detection; likewise, only Follow improved algorithm, ignoring the hardware performance can not achieve real-time high-speed.
control functions. Since the machine vision inspection system can replace human complete product testing, even at higher speeds than humans and efficiency, and therefore high-speed machine vision become a hot issue in recent years, domestic and international research.

The data in Table 1 correlation analysis, the correlation coefficient of $r = 0.9961$. Scatter gram is shown in Figure 2.

![Figure 2. The measurements scatterplot of micro mobility and machine vision inspection system](image)

This can be seen, the system of measurement of small changes to reflect the same with high uniformity, it is effective to distinguish. It should be emphasized that the resolution and overall system configuration machine vision inspection systems, and image quality finally obtained are closely related. Therefore, before using sub-pixel algorithms, the best start from the lighting conditions, the imaging lens and image pre-processing and other aspects to improve image quality.

To more accurately measure the target speed, the author considers it necessary to detect the target when the target is accurate three-dimensional modeling, and rich enough to join in tracking features to ensure real-time target objectives, accurate tracking. You want the image distance consider the shape of the target vehicle, including color, height and width, and so on.

IMAQ Vision Builder is an interactive environment, users without programming application solutions quickly to image prototype design process. And make it operational and real-time data acquisition capability through real-time code generation LabVIEW work WE strengthened.

As the machine vision inspection system to be measured by detecting the edge of the main object to be obtained information, so the effective resolution is the effective resolution of the edges of objects.

Every mobile 2um, continuous movement 18um, obtain the following experimental data, shown in Table 2. Table, s represents the amount of micro-displacement, n represents the number of measurements under the same micro displacement.

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On the data in Table 2 correlation analysis to obtain a correlation coefficient of $r = 0.9905$. Scatter gram as shown in Fig 3.

It can be seen, the measurement system for the small changes to reflect the same with high consistency, it is effective to distinguish. This method can also be used for machine vision inspection system calibration.

LabVIEW is a graphical programming language based on program code. It provides a lot of image preprocessing, image segmentation, image understanding of libraries and development tools, and the user simply by connecting icons in the flow chart will require sub-Val (Virtual Instruments, LabVIEW development process) can be completed to connect the target tasks. Any V1 has three parts: the user interface, flow charts and icons connector interactive. LabVIEW graphical programming scheme simple programming is a very useful software development. LabVIEW in machine vision measurement system image processing software programming and general thinking in image processing is the same, so have a good compatibility.

Through the study of machine vision technology and the long delay Detection in the circuit breaker, the machine vision technology a new breakthrough in new areas, to achieve a long delay circuit breaker testing automation, improve production efficiency, increased social benefits and social competitiveness.

![Figure 3. Micro mobility and machine vision inspection system measurements scatterplot](image)
However, the exact speed of this pure vision in the field of intelligent transportation is still a problem, is still in the theoretical stage, the main difficulty lies in the speed-based target identification first requires object recognition, localization algorithm and speed algorithm based on image characteristics, etc.

IV. CONCLUSION

Based on Machine Vision gun should not assist in other non-visual equipment (radar, laser, etc.), it relies on only a single camera equipment captured video images (monocular imaging), by image analysis, automatic target recognition application aerospace technology (Automatic Target Recognition, ATR), the vehicle is detected within the target lane to identify and track its trajectory, accurate within a certain time to get moving distance computing velocity, can truly "seeing is believing."

With the development of machine vision technology, intelligent transportation system will be able to get a greater degree of support in system stability, efficiency and applicability and so on. With the development of wireless sensor networks, intelligent transportation systems will achieve the things raised was - things. For visual speed system, the future will have a better target detection and tracking algorithms and image locating algorithm.

We hope that our research in the future will be more advanced methods and technologies emerge, hope this technology will mature and be well applied as soon as possible, lay the foundation for intelligent transportation industry for the arrival of the era of things, in order to continue to promote a harmonious society the development of power.

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REFERENCES