

INTRODUCTION OF THREE-DIMENSIONAL MEASUREMENT TECHNOLOGIES DEVELOPED AND APPLIED IN SUZUKI MOTOR CORPORATION

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Abstract:

Suzuki Motor Corporation (SMC) recognizes the importance of collaborative projects with Universities and how it contributes to technological development effectively. In spite of the world economical depression, several projects could get started this year led by SMC. As a researcher of SMC, Author takes charge of two collaborative projects and introduces these as typical examples of the most successful collaborations. The first is, "3D Measurement System for Crash Tested Car" at Shizuoka University (Japan) and Budapest Tech Polytechnical Institute (Hungary) from 2008; the second is, "High-Accuracy Stereo Vision System Based on Phase-Only Correlation (POC) and Its Application to metal Component Inspection" with Tohoku Univ. (Japan) 2003-2005. By these collaborations, the profound knowledge of universities has a lot of possibility to suits the technical needs of SMC.

Keywords: image measurement, 3D measurement, Direct Linear Transformation (DLT) methods, Phase-Only Correlation (POC) function.

1. Introduction

Industry-University Cooperation is considered very important in Japan so that government orchestrated Implementation Guidelines [1] and defines several merits.

1. The development of new business fields and improvement of industrial technologies for industry.
2. The advancement of learning, and vitalizing of research activities for universities.
3. The contribution to facilitation of the transformation of Japanese State's industrial structure for politics.
4. The sound development of the national economy for people.

In our opinion, there should be also 5th, "the advancement of long term communication which gives chances to understand other researchers' studies deeply and to have strong inspirations". This article refers subjects, solution and development of two collaborative projects about 3D measurement.

1.1. "3D Measurement System for Crash Tested Car" with Shizuoka University (Japan) and Budapest Tech Polytechnical Institute (Hungary) since 2008

1.1.1. Subject

The car assessment of crash tests [2] has important role in the safety traffic society. About the check list of the car assessment, measurements of crash test dummies account for a large percentage. Although crash tested cars have a lot of information, these are abandoned after only a few measurement because the measurement of crash tested car is time-consuming job with many deformation points. The technology of quick and easy 3D measurement for crash tested car is needed. Using the technology, authors take particular note of the car cabin at first.

1.1.2. Solution

- A. The technology of 3D measurement of many points at once by putting markers on special points.

Using only one camera, the stereo camera effect, which originally needs two cameras, is got. Without the measurement of camera positions, it is able to calculate by control points. The control point model needs relativity of 3D measure points beforehand to be measured. It is very easy that a control point model is put in a cabin (Fig. 1). This measurement uses the Direct Linear Transformation (DLT) method [3].

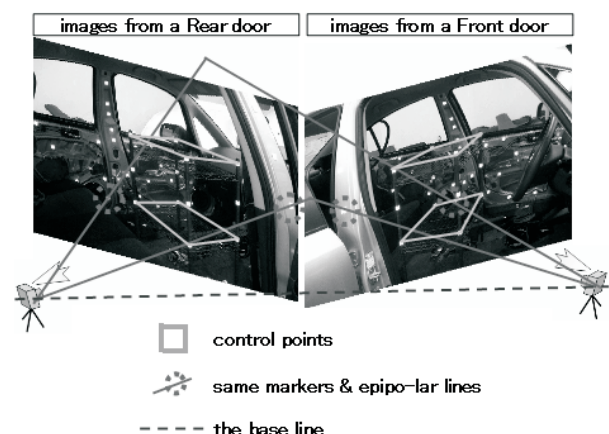


Fig. 1. Images of reflection markers in the car.

- B. The technology of 3D measurement by probe camera and stereo camera.

For measurement of detailed surface shape, the technology of 3D scan measurement is needed. The handling of probe camera is free and easy in the car cabin for measurement of surface shapes. The stereo camera measures the position and the posture of probe camera. For only standardized small size cars, the stereo camera stay which has

long base line (1m) is set easily by a handcart (Fig. 2).

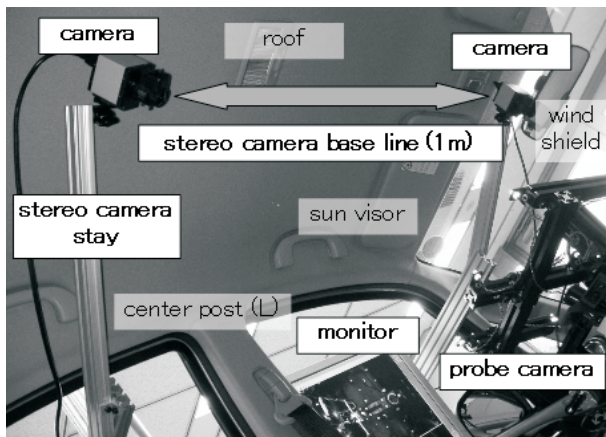


Fig. 2. Stereo camera system: base line (1m).

The probe camera is using the structured light method. The hand tool of probe camera has CCD camera (probe camera), laser-projector line pattern and LED markers for measurement by stereo camera.

1.1.3. Development

These technologies will be developed from usual tests to in-depth surveys for the safety traffic society. The data of 3D scan measurement will be used in the Computer Aided Engineering (CAE). The CAE will be a help for new safety car design. And this will connect to cost down by the cutting down the number of times for crush tests.

The application of these technologies is not only for crush tested cars but also non-crush cars. It will be used at the design for the trial manufacture, at the sales promotion for the comparison the style of driver to the shape of driver sheets and upholstery, and so on.

1.2. "High-Accuracy Stereo Vision System Based on Phase-Only Correlation and Its Application to metal Component Inspection" with Tohoku University (Japan) 2003-2005

1.2.1 Subject

The technology of image recognition is used in many industrial factories. For example, image measurement, fault detection and auto reading of printing. In the 2D measurement, the central point of a hole is recognized just as a circle, ignoring the thickness of objects. For the hole of thick material as cylinder the new technology is needed. And the extremely precise measurement is needed for engine cylinder, central pivot of motorcycle, and so on.

1.2.2. Solution

Authors notice two common properties of the hole of thick material of cylinder in industrial factory. The first is through-hole. It is widely used because it is easier drilling way than the depression-hole. The second is that it has a pattern on the surface of cylinder when it is drilled. These two common properties are able to be used for image-matching and LED-light setting behind through-hole (Fig. 3).

In this case, The POC matching and the hierarchical matching are applied. As multi-camera 3D measurement system, some stereo camera set side by side are used. 3D points of cylinder surface are given by the binocular disparity of part of left and right camera vision (about 32x32 pixels). The 3D points of cylinder surface are restored and fitted to the geometry cylinder.

The high-accuracy stereo vision measurement of through-hole is able to calculate the central point, radius and direction as axis [4].

In addition to the POC matching and the hierarchical matching (Fig. 4), the technology is based on POC function and correlation function used in the phase-based image matching to evaluate similarity between two images. The peak value of the POC function is able to be used as an efficient measure for stereo correspondence as binocular disparity. The technology is used at the high-accuracy passive 3D measurement [5] and the certification of fingerprints.

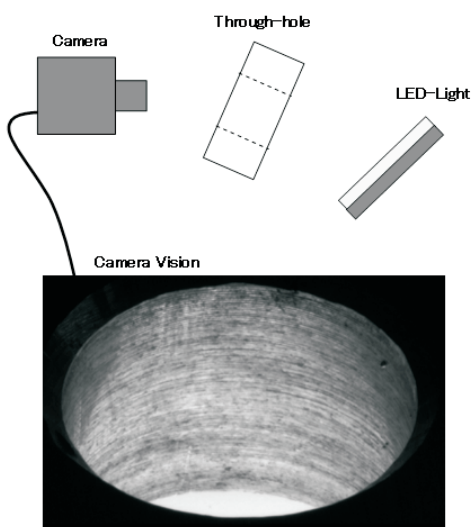


Fig. 3. Camera vision of the through-hole.

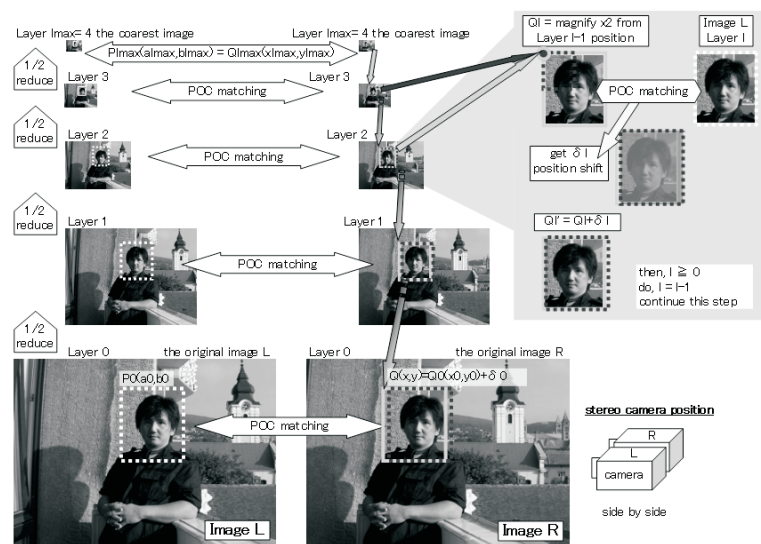


Fig. 4. The POC matching & the hierarchical matching.

1.2.3. Development

A new auto measurement and auto inspection machine for the motorcycle frames is produced. The motorcycle frame has twenty thick cylinder through-holes for setting the motorcycle engine, rear shock absorber, and seat rails. Without a new machine, the piercing inspection (Fig. 5) was used. Fig. 5 shows piercing inspection tool pin and block with through-hole on the work. The inspection tool block has holes which are the same position of the motorcycle engine or rear shock absorber or seat rails. In SMC factory, the piercing inspection about 90 seconds is used all motorcycle.

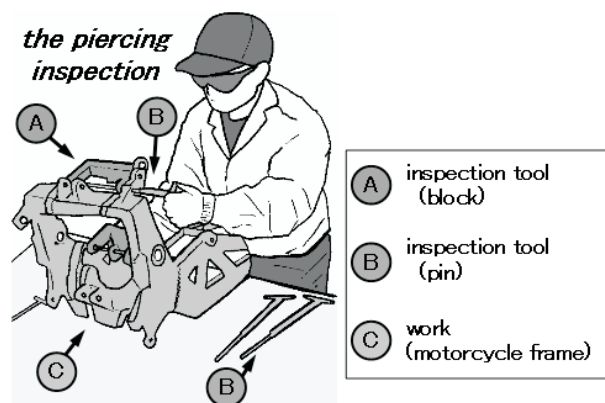


Fig. 5. The piercing inspection.

For 90 seconds measurement, this machine has three Cartesian robots. For check all holes, about twenty, motorcycle frame is turned 180 degree. Unfortunately, POC matching technology is not used in this machine because speed is much more important than too much accuracy. Substitute measurement technique includes the LED-light set behind through-hole and laser (Fig.6).

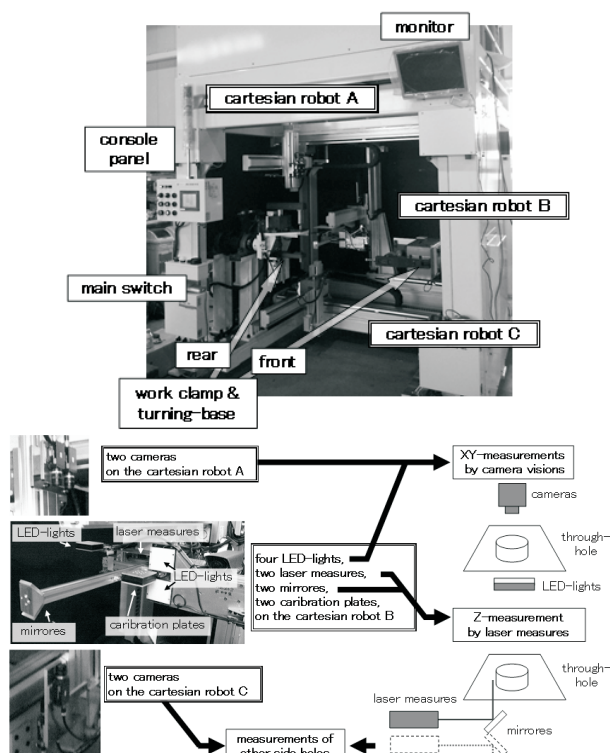


Fig. 6. The auto measurement and auto inspection machine for the motorcycle frames.

The data which can be used not only for inspection but also for measurement will be able to contribute in the extremely precious design, the cost down by stopping the production line in advance to prevent incident of off-specification product and the guarantee of quality.

1.3 Discussion

Both of the collaborative projects gave not only solutions of subjects but also developments. It is not limited to these two cases. Other researchers of SMC succeed to "3D head pose and gaze direction tracking" study [6]. It is development of one collaborative project started with a problem of factory [7]. How many technical needs does SMC have? Author thinks that the number of problems is the number of the technical needs. All executive and director check SMC factories in every autumn and always find new many problems. The subject in this paper was found in factory by them. As long as problems can be found, technical needs have no end.

To find solutions of problems and find ways to develop, knowing what we have and what they have is very important. But, generally, corporations tend to close its information to outside while universities open to public. To bridge the gap and convey corporation's intentions to universities, researchers of corporations have to prepare several things.

For example, the explanation of its problems, context, similar problem in other post, other corporation proceeding, predictable changes of a product by solution, effects of a new product, and so on. These preparations lead a useful collaborative project within a given period of time and a base of developments.

Author thinks from own experiences, the longer the term of collaborations is, the easier we understand each other and get the most out of our knowledge. Importance of researchers' communications is always the same during and after collaboration period.

2. Conclusions

Collaborative projects give SMC not only solutions of subjects, but also developments. Profound knowledge of universities has a lot of possibility to suits the technical needs of SMC. SMC always needs technical solution and developments. SMC recognizes the importance of collaborative projects with Universities and how it contributes to technological development effectively.

There is no doubt that the advancement of long term communication gives chance to understand other researchers' studies deeply and to draw strong inspirations.

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