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METHODS OF PROCESSING POINT CLOUD TO ACHIEVE IMPROVEMENT DATA POSSIBILITIES

Summary: This article discusses the possibility of processing point cloud data for further processing in other systems for instance inspection, measuring systems and etc. The main focus of this papers is to supplement physical possibilities of scanning device. Appropriate processing method for improvement is able to fundamentally improve quality of obtained data and secondary save financial expenses for hardware used in the system. In general, every method is appropriate for achiever better result in the specific aspect.

Keywords: profilometer, point cloud, processing, regression

METODY PRZETWARZANIA CHMURY PUNKTÓW W CELU POPRAWY JAKOŚCI DANYCH

Streszczenie: W artykule omówiono możliwość przetwarzania danych w postaci chmury punktów, aby umożliwić ich dalsze przetwarzanie w innych systemach – na przykład dla celów takich jak inspekcja, przegląd oraz użycie w systemach pomiarowych itp. Głównym problemem rozważanym w niniejszym artykule jest wszechstronne rozszerzenia możliwości działania urządzeń do skanowania 3D. Zastosowanie odpowiednich metod przetwarzania umożliwia – po pierwsze - istotną poprawę jakości otrzymanych danych, a po drugie – na zmniejszenie kosztów ponoszonych na zakup urządzeń i podzespołów używanych w takich systemach pozyskiwania danych. W ogólności, stosuje się różne dostępne adekwatne metody, algorytmy oraz procedury, aby uzyskać lepsze rezultaty w szczególnych aspektach, czy dalszych zastosowaniach.

Słowa kluczowe: profilometr, chmura punktów, przetwarzanie, regresja

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1. Introduction

Every inspection or measuring system is based on two main attributes that obtain data and its processing. The first case obtain is based on choosing an appropriate device, which is able to offer data in sufficient quality for further processing and its post-processing in a specific system. In the beginning design of inspection systems is necessary to define the main aim and suggest appropriate hardware to achieve data. In this step, generally the most used systems are camera vision systems, laser scanning system and etc. If the main aim was chosen obtaining geometric data, is appropriate choose between camera systems supported laser line or laser profilometer. In the case of camera systems are the main advantages of multi-data collection like geometric or visual data in the grayscale or color image. These types are appropriate for a more complex system using only the visual system. The main disadvantage is in liming resolution based on camera resolution. The high-resolution camera is able to offer sufficient resolution but on other hand puts high demands on computational hardware [1]. Laser line scanning based on profilometer scanning geometric characteristics with an appropriate resolution for instance use in an inspection system [2].

2. Object and system requirements

Choosing of object was establish based on main focus of works authors this papers. The main aim is developing system to detect defection on the tire. Database of detection was defined according to experiences from Tire manufacture. Some defects are shown in Figure . Types of defects is possible to categorize to the two main areas and its:

- Geometric defects (Impurities, mechanical integrity damage, large cracks)
- Visual defects (cracks, impurities in surfaces)

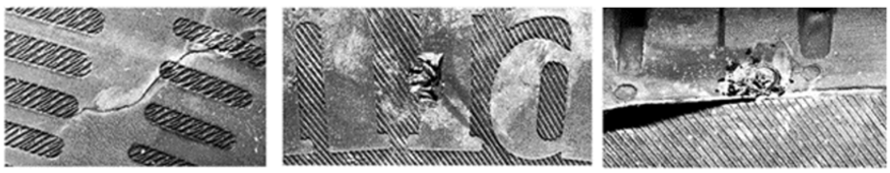

Figure 1. Examples of defects (first - crack, middle, last - mechanical integrity damage)

Geometric defects were chosen like primary focus. It's possible to capture these defects via a camera system or a laser scanning system. In the case of camera systems, it is necessary to establish appropriate lighting systems, which is able to highlight edges in capturing images. Limitations of this method are in the location of lights in space of inspection systems. In specific cases, lighting is not able to highlight edges and in final, this defect merges in the captured image illustrated in Figure 2. In this case it is also significantly impact of resolutions camera system, which is able to offer possibilities to detect very small defects but on the other hand, it places high demands on computing performance [3, 4].

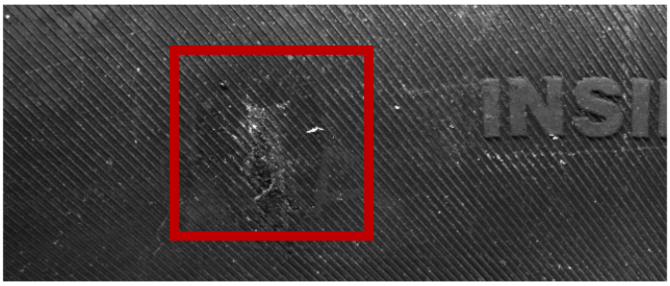

Figure 2. Defect - mechanical integrity damaged

Inspection system using a laser scanner is able to scan captured types of defects. [5]. The sufficiently working system is working with the condition, that size of defects is any multi play bigger than is resolution of scanning device. According to his condition is possible to define the premise, that it has to be chosen device with has multiply higher resolution or detecting defects are multiplied bigger than the resolution of the used device. Scanning of the sidewall of the tire was performed by scanCONTROL 2600-50 [2].

3. Captured basic data

In Figure 3 is showed the place of the defect (impurity) [6, 7]. There are white places, which meant missing points from point cloud. It is a consequence of surface relief, which reflect off laser beam out of scanning device. This is illustrated on letters, where the leading edges are in the form of a continuous surface and exit edges are without captured points and displayed like gaps. Filling these gaps is possible in various ways. It is crucial to realize the size of the gap according to the whole size [8].

The simplest approach is possible by filling the base on polynomial regression or mean matrix. Every method is suitable for an individual case. Polynomial regression is suitable for filling bigger gaps like 3 missing points. The number of missing points is based on number missing all points in line, the distance between two nearest knows points and average standard distance between nearest points (D):

$$D = \frac{X_{g\max} - X_{g\min}}{639} \tag{1}$$

where:

- $X_{g\max}$ - global maximum X value from point cloud,
- $X_{g\min}$ - global minimum X value from point cloud,
- 639 – number of points in one line without one place.

For more like 9 missing points in the area (matrix 3 x 3) is appropriate polynomial regression in line, which is able to replace a higher number of missing values include border points. Mean matrix method is appropriate for adding one missing point in matrix 3 x 3.

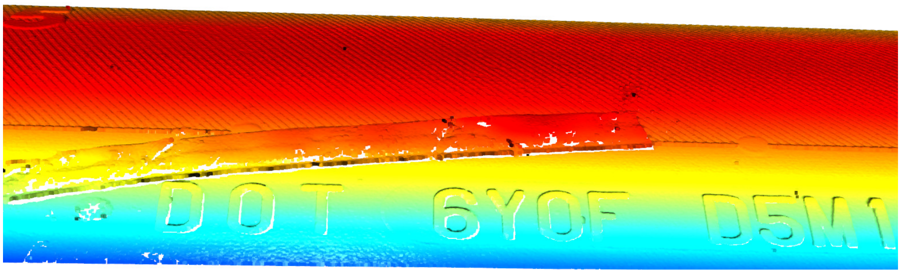

Figure 3. Basic point cloud

4. Supplement point cloud based on polynomial regression

As mentioned above, this method is suitable to supplement missing higher number of point in one place. Polynomial regression is possible if it is defined as a sufficient number of points and its reliability has a correlation with a higher number of these points. The most important are values in X and Z axis in line, which define a profile. For the better result is appropriate to use more complex polynomial regression. For using the system it is possible to use maximal 7th-degree polynomial. With a higher degree of a polynomial is possible more accurate mathematically define the real surface.
Z values are computed based on X values. It is necessary to compute missing X values. This is possible to throw linear regression of line. Linear regression is based on values and their position in line.
Finally, the creation of fully generate surface is illustrated in Figure 4, which supplement basic point cloud.

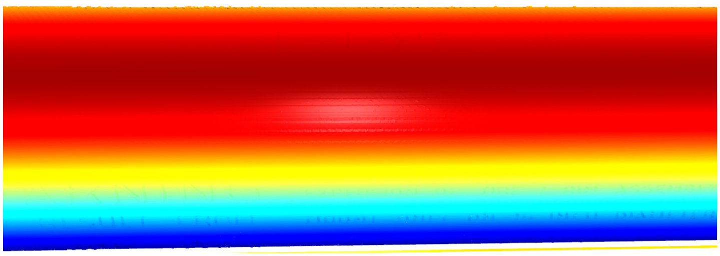

Figure 4. Fully generate surface based of polynomials

In figure above it is possible to recognize indication of letters but no evidently. This indicate insufficient computing points. In result, supplemented basic point cloud displayed in Figure 5 contain remained big gaps displayed like white place in surface.

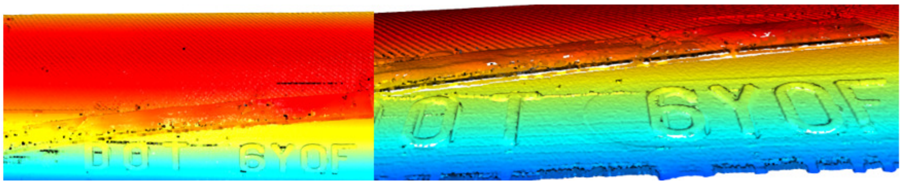

Figure 5. Supplemented basic point cloud

5. Supplement point cloud based on Mean method

This method is different from the above-described method in size of modifying or supplement points in the cloud. This way is not compatible with high supplementing for instance in the case of missing matrix 3 x 3 and bigger. This method is suitable only in supplemented borders of gaps. It is for a reasoning computing mean value from specific number points. Mean algorithm for Z_m values was set up:

$$Z_m = \left\{ \frac{\sum_{i-2,j-2}^{i+2,j+2} A_{i,j} > 0}{num(A_{i,j} > 0)} \quad if \left(\left(\frac{f_{\max}(Z)}{5} \right) < \left(\frac{\sum_{i-2,j-2}^{i+2,j+2} A_{i,j}}{25} \right) \right) \right. \tag{2}$$

The basic explanation of the mathematically described algorithm above defines how the point cloud is supplemented by mean values calculated from a matrix with size 5x5. In this way, it is not possible to fulfil all gaps in one step. So, it is necessary to perform this method in the iteration. Other limitations mean method in insufficient fulfils gaps in the border in point cloud because of the design of the algorithm. In many iterations number of gaps is converging to a specific value, which characterizes a number of gaps in borders point cloud. Number of gaps in iterations is illustrated in Figure 6. In first iterations, there is a significant fall of gaps. And from 6th iteration gaps number converge to specific value.

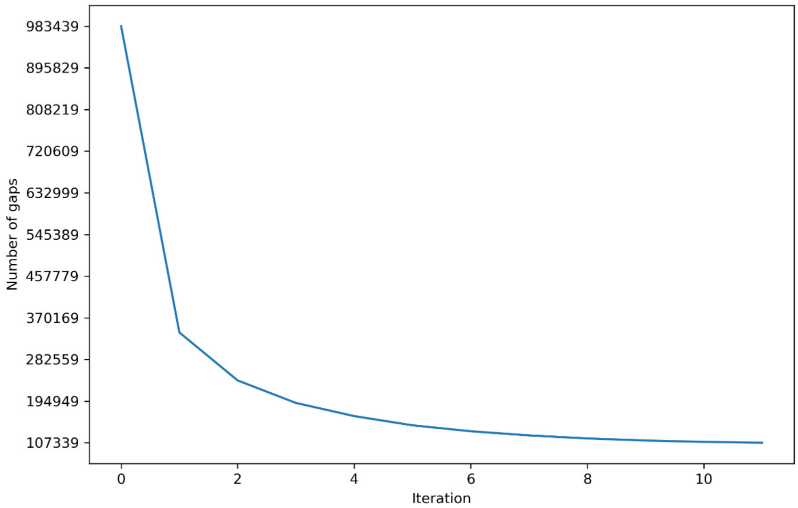

Figure 6. Number of gaps in iterations

6. Conclusion

In this paper, we were focused on the comparison between 2D and 3D scanning devices according to aim for further using data to another system for example in the inspection system. Other area deals with explaining importance processing DATA to improve physical characteristics scanning device, its advantages and disadvantages. In final data processing it should be appropriate in a superior system, which is able to effective working. For 3D data, two ways of improving the quality of data were mentioned. In both method were highlighted suitable using and possible quality of output data. In further work is appropriate to improve method mainly in case of Mean method to fulfil gaps in borders. Improvement in the polynomial method is possible to assimilate supplement values to nearest origin points to achieve more interconnected surface. Also, it was possible to combine both methods to one system with the possibility to raise double resolution in the x-axis.

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