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Research on Welding Deformation Detection of Vehicle Body Components Based on 3D Point Cloud Processing

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Abstract

Welding of vehicle body structure parts is one of the key processes in the production of vehicle body, and welding deformation detection is costly and requires a lot of resources and equipment support. Currently for the vehicle body parts welding deformation detection of the traditional method of welding high temperature reliability and feasibility can not be guaranteed, the measurement efficiency is low, can not get the full-field strain results, but also difficult to apply to the measurement of welded parts and other issues. The method of 3D laser scanner measurement of welding deformation solves the problem of difficult positioning of the measurement point due to high temperature, and can accurately calculate the angular deformation, bending deformation and other problems in the welding deformation process. This thesis summarises the existing methods of 3D point cloud data processing, and highlights the current research status of specific algorithms for point cloud denoising and point cloud streamlining, which provides guidance for subsequent welding work.

Keywords

Point cloud filtering, point cloud streamlining, welding deformation detection.

1. Introduction

Material welding in the military field, aviation industry, automotive industry, shipping industry applications occupy an important position, the mechanical properties of materials at high temperatures in welding research is to ensure that the welded structure in the industry or life in the normal use of the key, welding deformation detection is one of the important basic research in the mechanics of material forming, the current deformation of the material in the welding of the dynamic measurement of the bottleneck in the research, usually need to carry out a number of repeated. Measurement to meet the requirements, and the traditional measurement methods (such as strain gauges) and other welding at high temperatures under the reliability and feasibility can not be guaranteed, the measurement efficiency is low, can not get the full-field strain results, but also difficult to apply to the measurement of welded parts. Therefore, researchers at home and abroad have spent a lot of time to design a variety of methods for welding deformation measurement.

At present, scholars at home and abroad on the study of welding deformation mostly use numerical simulation methods, which can be used to study the evolution of the welding process stantaneous stress, strain at a relatively low cost, but also to examine the welding process conditions on the joint residual stress and deformation of the impact of welding deformation, to master the welding deformation law, the development of a scientific welding process, but most of the time, due to the complexity of the welding process, the mechanical properties of the material during the welding process with the temperature is highly nonlinear changes, resulting in convergence difficulties; the existence of high-temperature zone makes the control of numerical simulation of the accuracy and stability of the existence of certain difficulties, it is difficult to accurately predict the deformation distribution of thin plate in the welding process, so the deformation distribution of the welding process of the actual measurements, you can check the credibility of the numerical simulation, the resulting data can be used for the control of weld deformation, the selection of welding process design and the reserved deforrmation of the amount of determination to provide a reliable basis, but due to the presence of high temperature, harsh environment, strong electromagnetic interference, deformation of factors affecting more than one reason, the traditional means of deformation measurement, such as strain gauges, displacement sensors, etc.,there are large errors in the results of the measurement, can not be measured at the same time the 3D deformation of the multi-point, and even more unable to get the entire deformation of the surface of the welded surface of the dynamic change of the deformation field process. In the past two years, some scholars began to try to use visual methods to obtain 3D point cloud data to measure welding deformation.

2. Research status of point cloud acquisition and processing methods

In recent years, welding deformation detection of body parts based on 3D point cloud processing has been widely used due to its high detection efficiency and accuracy. At present, the common acquisition methods of 3D point cloud include visual measurement and laser scanning measurement, of which visual measurement includes binocular camera detection, RGB-D depth camera detection, etc. Visual measurement 3D point cloud acquisition technology uses the information in the image to reconstruct the 3D shape of the object. When choosing a specific method, it is necessary to consider factors such as application scenarios, cost, accuracy and real-time performance. These methods are usually sensitive to lighting conditions, image quality and camera calibration. In contrast, laser scanning technology is suitable for applications that require a high degree of accuracy. With the advantages of on-site measurement, non-disturbance of the measurement object, multi-point measurement， high 3D accuracy, fast response time, large range flexibility, and abundant measurement results, it is very suitable for measuring and evaluating complex 3D deformation processes in the welding process.

In the welding deformation detection of body parts based on 3D point cloud processing, it is necessary to carry out the 3D laser scanning point cloud data processing process as shown in Fig.1.Firstly, a 3D laser scanner is used to collect the point cloud data of the welding deformation results, and the original 3D laser scanning data is collected. The point cloud pre-processing of the collected values includes data noise reduction and data streamlining. Finally, the corresponding 3D modelling is obtained according to the data.

2.1. Processing method based on point cloud denoising

Due to various factors such as the accuracy of the point cloud acquired by the device and the external environment, it is inevitable to obtain noise point clouds, so it is necessary to denoise the data. Frequently used point cloud filtering algorithms include straight pass filtering, statistical filtering, bilateral filtering, voxel filtering, radius filtering, etc. Take bilateral filtering as an example, the flow chart of the algorithm is shown in Fig. 2. A 3D laser scanner is used to collect the point cloud data, and the point cloud topology is established on the data, so as to make a quick neighbourhood query on the sampled points to determine whether the distance is greater than the distance threshold, and then the bilateral filtering method is used if the distance is greater than the distance threshold, and then the planar projection method is carried out if the distance is greater than the distance threshold, then the bilateral filtering method is carried out if the data are not.

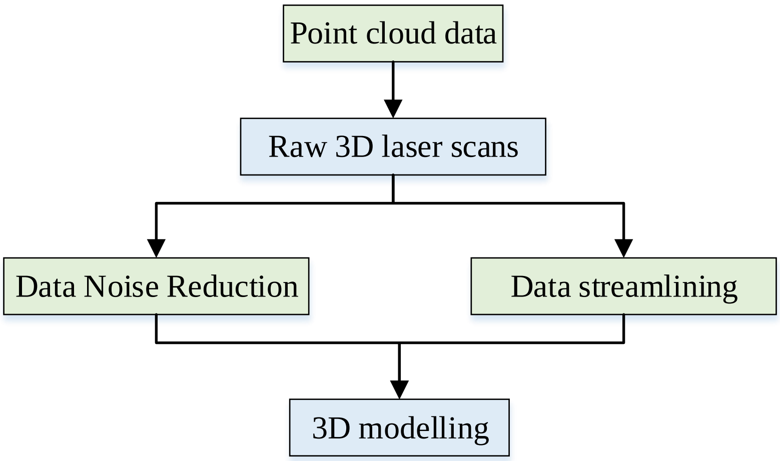

Fig. 1 Flow chart of point cloud data processing

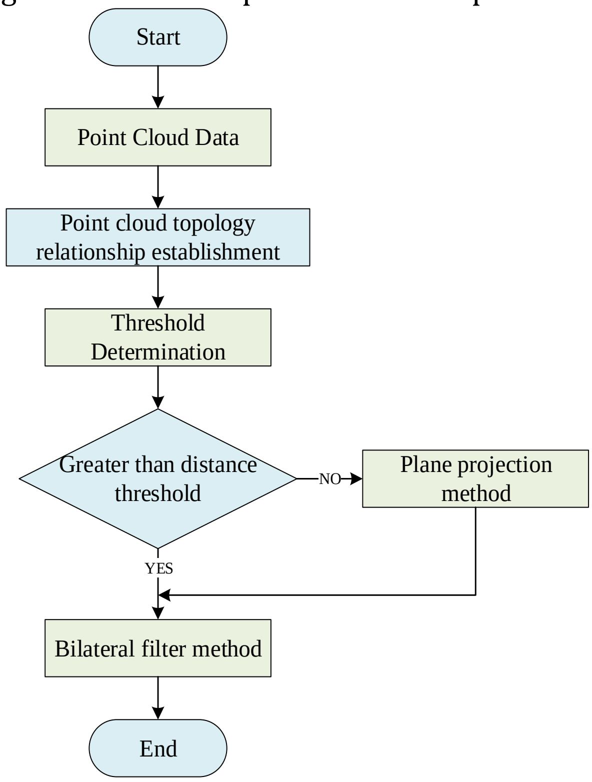

Fig. 2 Point cloud denoising flowchart

Scholars at home and abroad have carried out a lot of research on the above point cloud denoising algorithms. Desbrun et al. [1] developed a mean curvature flow based filtering algorithm for regular point clouds, which maps the changes in the geometric features of the measured object according to the difference in the mean curvature, and can effectively suppress the noise points and retain the target's contour, but the surface of the target will be curved to a certain extent in the process. Lee et al. [2] developed an adaptive generation of filter SAF according to the dynamic distribution of neighbourhood points, which performs well in removing the noise points and anomalous points. Schall et al.[3] proposed a filtering algorithm that identifies noise from smooth surfaces and focuses on denoising them. The algorithm assigns a likelihood measure to each point to obtain the probability of the noise on the surface in order to be able to detect noise of various amplitudes. Zhu, Xiaoxiao et al.[4]used a statistical histogram to remove the noise points, and then the point cloud data were gridded and indexed, and then the surface equations were constructed by using the lowest points of all the grids, and the noise reduction of the point cloud data was done by comparing the difference in elevation of the points, which effectively reduces the sensitivity of point cloud filtering algorithms to the point cloud density.Feng Lei et al. [5] used raster to identify the different connectivity domains in point cloud data and segmented the point cloud into masked and unmasked regions, this method is not affected by the point cloud density, but it is only effective in deleting the outliers. Zhang et al. [6] developed a new filtering algorithm based on the asymptotic morphology, which takes advantage of the differences in the slope of the terrain to set the corresponding thresholds of elevation differences in different sizes of the window, the disadvantage of this method is that in the case of the point cloud with different elevation differences, the filtering algorithm can only reduce the sensitivity to the density of the point cloud.The disadvantage of this method is that it may produce a large error in the unsmooth area.Guo Jin et al.[7] used k-mean clustering method to differentiate the noise points from the valid points and remove the noise from the point cloud data, and smoothed and filtered the local areas.Wu Lushen[8]used curvature feature weights to divide the point cloud data into two regions: flat region and edge region, and used specific filtering algorithms for denoising the characteristics of different regions.

2.2. Current Research Status of Point Cloud Data Streamlining

Since the collected point cloud data is relatively large and not directly applicable to the subsequent point cloud processing, point cloud data streamlining is a very necessary operation.
The point cloud data reduction is a very necessary operation.Point cloud data reduction ensures that the characteristics of the point cloud are maintained as much as possible, and replaces the original redundant point cloud data with fewer point clouds, so that the point cloud data can be prepared for subsequent 3D point cloud analyses.Before point cloud data reduction, it is often necessary to construct a spatial topology of the point cloud data so that a fast neighbourhood query can be performed on the sampled points.Common spatial indexing methods include the spatial cell method [9], BSP tree [10], KD-Tree [11], and octree [12].Common point cloud refinement algorithms include random resampling, voxelised grid downsampling, grid refinement, and kernel refinement.Fig. 3 shows the flow chart of point cloud refinement, which uses a 3D laser scanner to collect the point cloud data, establish the point cloud topological relationship, and divide the point cloud space into a regular 3D grid.Each grid cell is sampled and a representative point is selected as the representative of the grid cell. The point cloud is streamlined by removing other points from the grid cells.Point cloud streamlining reduces the weight of the point cloud data by directly reducing the number of points in the data while retaining the key features of the data, with the goal of improving the efficiency of data processing and analysis, and reducing storage costs.

Scholars at home and abroad have done a lot of research in the field of point cloud streamlining.Chen Y[13] and others used point cloud data to construct STL grid files, converted each point in the point cloud into a triangular shape, and then in the generated STL file, the streamlining of point cloud data was achieved by deleting or merging some triangular grids.Hong Jun [14] and others use the box method to divide the point cloud and store it in the order of scanning lines, and then use the geometric computation of the squareness-chord-height criterion to streamline the point cloud.Wang Hongtao [15] and others partitioned the point cloud into subsets, and for each subset, the centre of gravity is calculated and preserved, so that the density of the point cloud data can be significantly reduced, but some feature points will be lost.Liu Tao[16]proposed a method to simplify the point cloud by using the curvature change, which can retain the important feature points in the part with obvious curvature change, but when the curvature change is small, it may cause the generation of holes, which affects the subsequent processing of the point cloud.

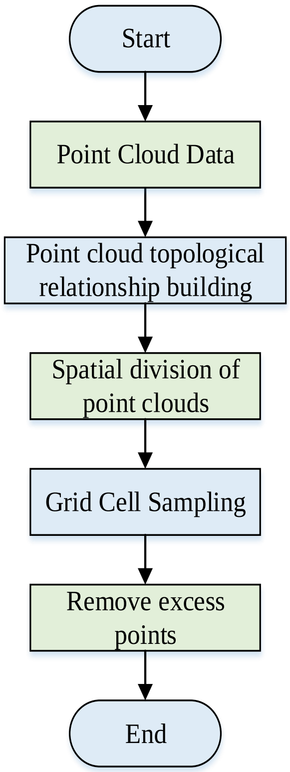

Fig. 3 Point Cloud Streamlining Flowchart

3. Research status of welding deformation detection methods

Domestic and foreign researchers have conducted a large number of welding deformation detection methods based on 3D point cloud research.He Hongwen et al. proposed a laser scanning measurement of welding deformation method, the method can obtain a fixed state of welding deformation field information, but can not get before and after the welding of the history of deformation process, Liu et al. [17]proposed a non-contact 3D dynamic intersection of the shape of the video measurement method, the use of CCD image sensors to continuously shoot the surface of the continuous deformation of the image sequence, the image processing through the 3D reconstruction of the surface of the weldment.The 3D coordinates of the marker points are reconstructed through image processing, and the marker points are tracked to obtain the overall deformation dynamic process of the welded surface.Hu Hao et al. [18] proposed a visual measurement method using digital scattering to track the deformation point, through the scattering images collected before and after the deformation of the two object surface to calculate the deformation field of the surface of the object, the development of the experimental system for thin plate welding deformation measurements and software for the study of welding deformation law provides an effective means of assessment.He Hongwen et al. [19]proposed a new method of applying non-contact 3D laser scanner to measure the welding deformation of the specimen, as shown in Fig. 4 and Fig. 5, drilling holes in the plate and placing a steel ball for precise positioning, before and after welding, the application of hand-held laser scanner for scanning the plate and the steel ball, the output of the corresponding point cloud file, the application of reverse engineering software Imageware before and after the welding of the component point cloud files before and after the welding of the component to analyse and process, and finally get the 3D coordinates of the ball centre of the steel ball in the vertical distance point on the welded plate, after getting the 3D coordinates of the measurement points before and after welding, the coordinates of the measurement points before and after welding for the difference operation, to get the displacement of the various measurement points, which can be used to calculate the angular deformation and its bending deformation of the plate.Wang

Lizhong et al.[20] used digital image technology to obtain welding images, by adding filters to inhibit the influence of flash on the inspection in the welding process, and then used the high precision matching method of scattered images to obtain welding images without the influence of flash, and finally through the Gaussian smoothing technology to achieve welding deformation detection.Wang Mingming et al. [21]used the method of time sequence matching to collect high quality welding images, and then used the method of visual inspection of scattered images to detect welding deformation, and finally used finite element simulation to achieve overall verification.Gu Jing et al. [22] implemented enhancement of the acquired welding signals by learning the DenseNet algorithm, and then used the deepening and widening network to enhance directional thinking, on the basis of which the recognition of welding deformation was achieved.


Fig. 4 Laser scanning site Fig. 5 Welding site of car body

4. Conclusion

With the progress of science and technology, the use of welding of body parts has been developed rapidly, and the parts are prone to deformation and defects under the high temperature of welding, so a practical deformation detection technology is essential.Therefore, a practical deformation detection technique is essential. Firstly, the parts before and after welding should be scanned to obtain the 3D point cloud data, and this paper reviews the current point cloud acquisition methods based on vision and laser.Secondly, the point cloud data should be pre-processed, in order to obtain more accurate data for processing, point cloud denoising and point cloud streamlining are the most important, so the existing algorithms for denoising and streamlining are analysed in depth.In the end, more accurate point cloud data can be compared and analysed to determine the deformation before and after welding, thus providing data support for subsequent improvements.

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