# Study on the stitching method of beam target infrared image based on global transformation

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◆As a beam diagnostic tool with the highest resolution, the 1D-CFC (one-dimensional carbon fiber composite) calorimeter can obtain the key beam parameters such as beam divergence, beam uniformity.

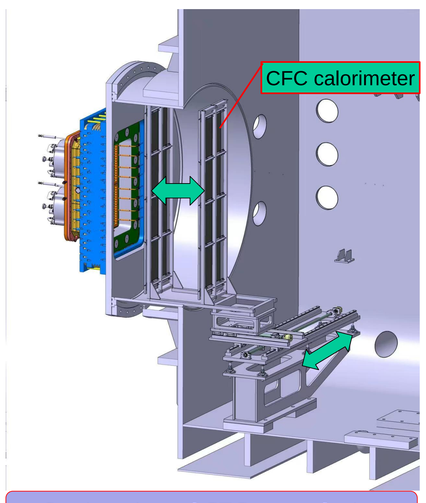
◆According to the design of accelerating system of ion source for CRAFT (Comprehensive Research Facility for Fusion Technology) NNBI (Negative Ion based Neural Beam Injection system), the CFC calorimeter is designed as a narrow and long structure with the size of 1800mm×680mm. In order to obtain a clear beam profile, two infrared cameras are used to photograph the temperature distribution of CFC surface. Considering the field of view in horizontal and vertical direction, incomplete diagnostic calorimeter infrared images with partially overlapping contents are obtained.

◆In order to analyze conveniently and obtain a complete and accurate image data, the two images acquired from the different infrared camera need to be stitched. In this paper, the global geometric structure of the image is preserved, the overlapping regions are matched using straight line and point features, and for the non-overlapping regions, constraints based on global similar transformation are introduced to reduce perspective and projection distortion, and show the single-view stitching results finally.

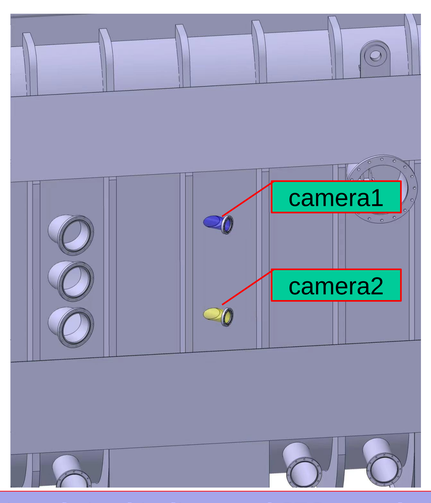
◆The experimental results show that this method can obtain pixel-level stitching results in the non-fixed viewpoint, which has stronger robustness and generality compared with the traditional method and can provide effective data for the next step of beam parameter analysis.

## *CRAFT NNBI Test Platform*

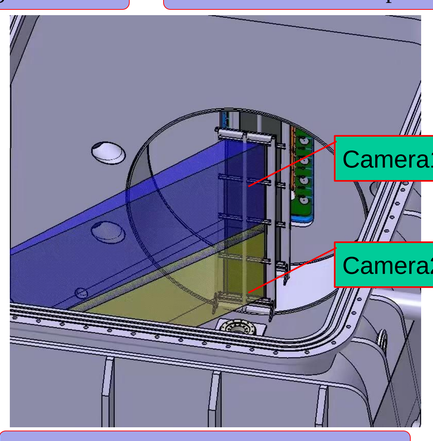
- The CFC diagnostic device is designed as a non-fixed device that can move forward and backward .
- The two infrared cameras are mounted on the same straight line, which is perpendicular to the ground. The infrared camera lens is horizontal, and the camera optical center is parallel to the ground .
- Because the height of the CFC calorimeter is too large, the two infrared cameras can only shoot a part of the calorimeter surface, and the shooting images have overlapping contents




Section view of CFC target device

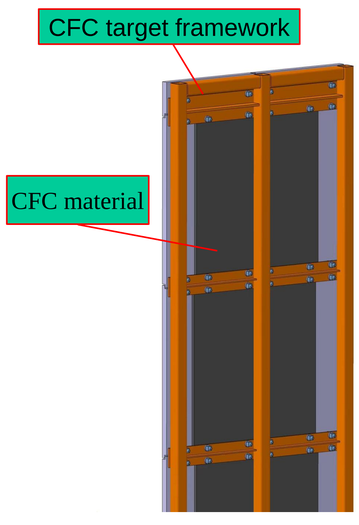



Position relationship diagram of CFC target device

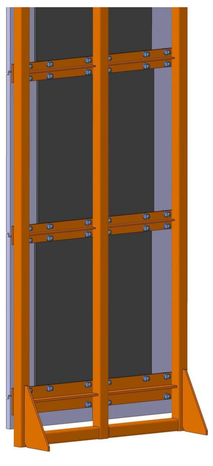



Map of the camera shooting area

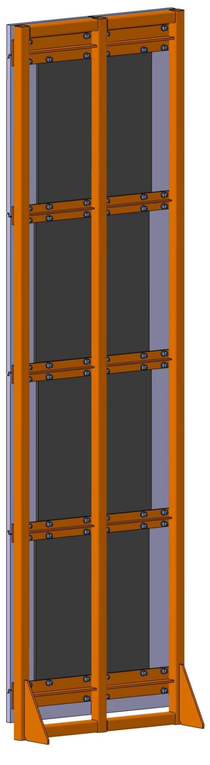
## *Camera shot image*




Camera shot image(Top half of the mockup)



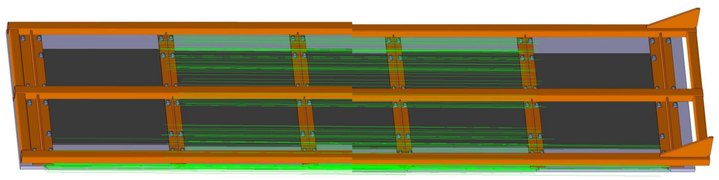
Camera shot image(Bottom half of the mockup)



Panorama mockup

- The black part of the image is the cfc target, and the rest is the target frame. Since the cfc is a black heat-conducting material and the frame is not heat-conducting, the infrared camera can capture the obvious frame shape in the experiment, so the point and line features of the frame are used to stitch two images

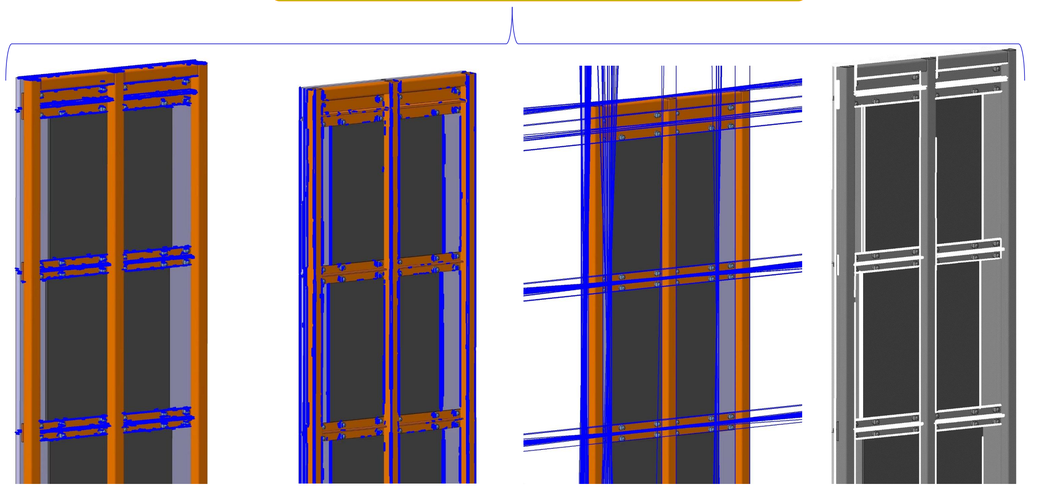
## *Traditional image stitching method: SIFT image stitching*



SIFT algorithm feature point matching results

- Many excellent image stitching algorithms use points as features for image alignment, such as APAP(As-Projective-As-Possible Image Stitching with Moving DLT), AANAP(Adaptive As-Natural-As-Possible), SPHP(Shape-Preserving Half-projective Warps for Image Stitching, etc. However, the experimental results show that feature matching does not perform well on this image, and there are significant errors in the matching results, causing errors in the image stitching results.
- The sift(Scale-invariant feature transform) algorithm stitching results are inaccurate and have obvious misalignment. Because of the high similarity of feature points and inconspicuous overlapping regions in this experiment, linear features are chosen as the stitching benchmark.

## *Comparison of image edge detection results*



Sobel operator x-direction detection results+LSD

Sobel operator y-direction detection results+LSD

Hough transform edge detection results

Probabilistic hough edge transform detection results

- Various straight line detection algorithms were used to process the images, and the processing results found that the most accurate straight line results were detected when the canny operator was combined with the possible hough transform algorithm. LSD(Line Segment Detector ) algorithm would cause many short line segments, and hough transform would cause too many results for the same straight line detection, and the results needed to be filtered.

## *Image stitching algorithm*

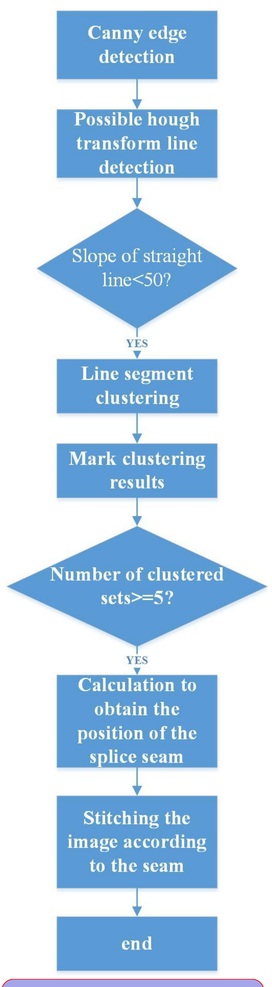
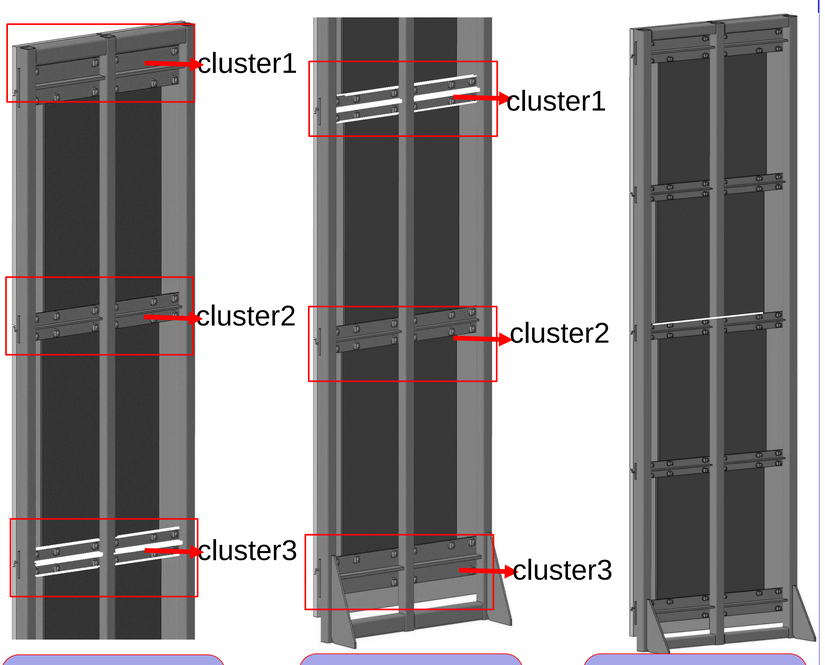



Image stitching algorithm flow chart

**Line segment clustering algorithm**

Input: $(X_1, Y_1)(X_2, Y_2)$ The two endpoints of a straight line
for i in lines：
  for j in lines：
    If（|xi-xi|<threshold） Adding straight lines to the same cluster
    Delete this line j from the line array
Sorting the clusters by endpoint coordinate size

Line segment clustering algorithm




Clustering results (Top half of the mockup

+

Clustering results (Bottom half of the mockup)

Image stitch results of panorama mockup

- As shown above, the white line segment is a set. Determine whether the number of two image collections is greater than or equal to 5. If yes, it means that image stitching is possible. Number each collection according to the coordinate size. Select the collection with the largest number as the alternative for the stitching seam of the image, and then calculate the stitching seam of the selected other image.
- In the two sets selected in the above step, two straight lines are calculated according to the coordinate relationship, which should belong to the same line in the stitched image, and the two images are stitched with this line as the stitching seam.

## *Conclusion*

The main purpose of this experiment is to find a gap as the stitching benchmark, use the line features of the device frame to find the accurate stitching gap, and finally get the stitching image. The corrected image can provide data support for obtaining key beam parameters.

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