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Optical plasma boundary reconstruction based on least squares for EAST Tokamak

Key words: Optical boundary reconstruction; Boundary detection; Global contrast; Least square; EAST Tokamak

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Motivations

1. Equilibrium and fitting (EFIT) code is generally used for plasma boundary reconstruction in some Tokamaks. However, this magnetic method is too time-consuming for some real-time applications.
2. Optical plasma boundary reconstruction method is fast and economy. However, this image processing based method acquire only boundary in the image plane without camera calibration.
3. Using EFIT reconstruction results as ground truth to transfer the optical reconstruction results from the image plane to the Tokamak poloidal plane by a mathematical model.

Methods

1. The global contrast is robust for the illumination variety. We define the significant value of a pixel by its contrast with the other pixels in a ROI.
2. The plasma boundary in the image plane is mathematically represented by polynomial. And it can be transformed to Tokamak poloidal plane through a transformation matrix.
3. Solve the transformation matrix by minimizing the reconstruction errors with the least squares.



Fig. 1 Video images. The images represent 0–10 s shots in order. References to color refer to the online version of this figure

Major results

1. Our method can extract clear plasma boundaries of different ROIs.

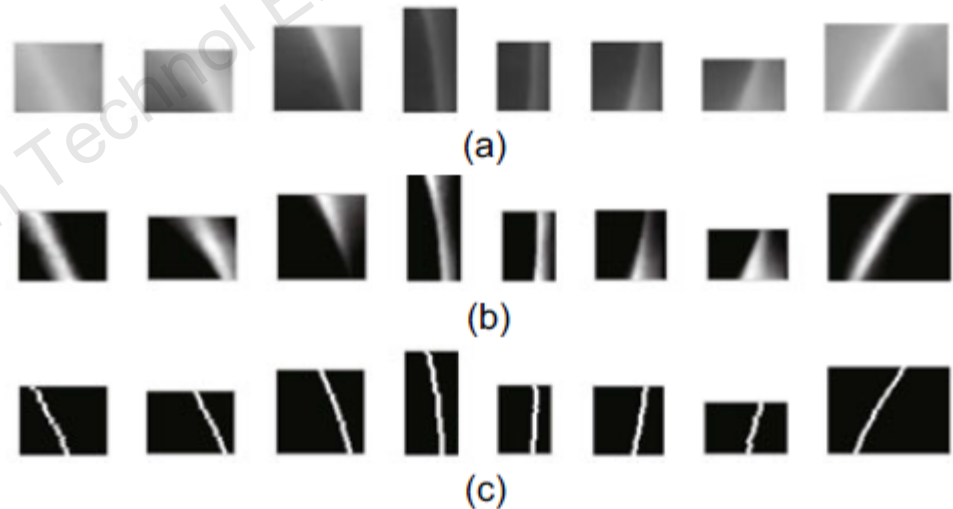
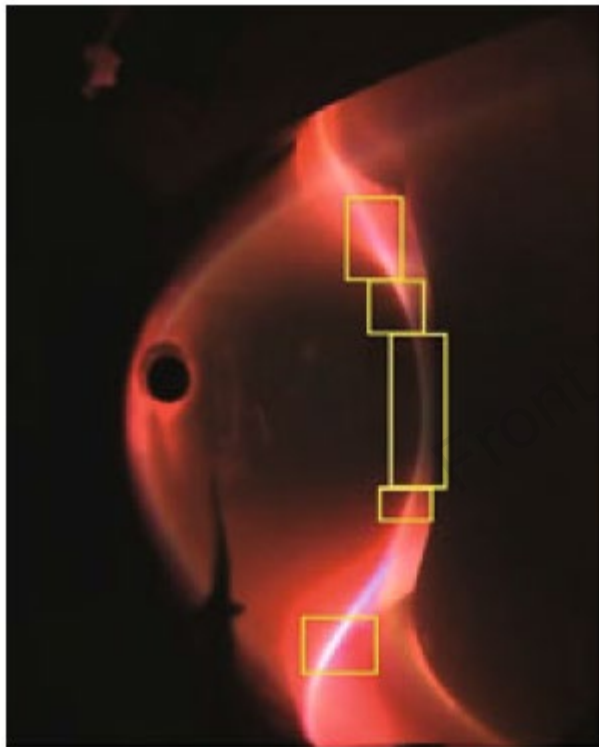


Fig. 4 Plasma boundary detection of all ROIs: (a) original gray-scale images; (b) probabilities graphs; (c) edge detection results

Major results

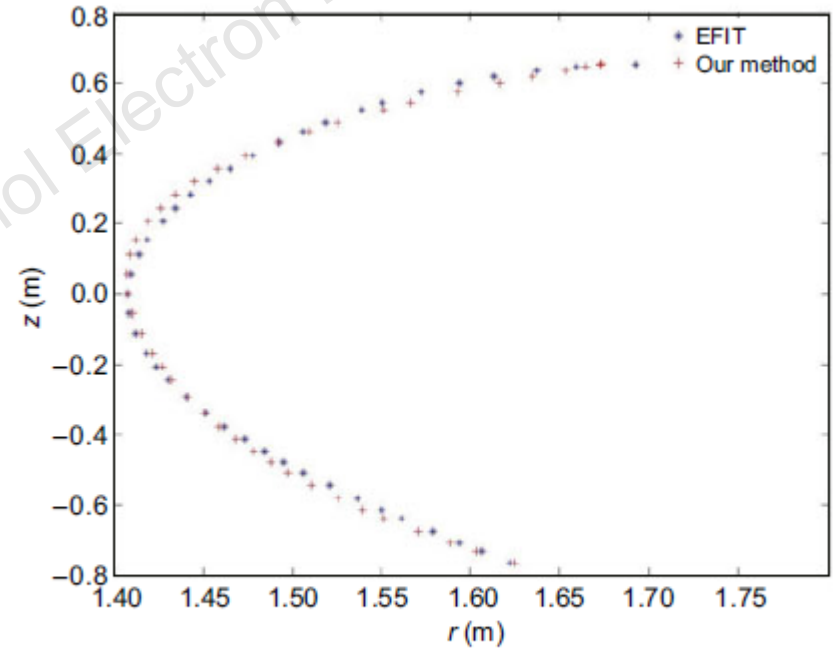
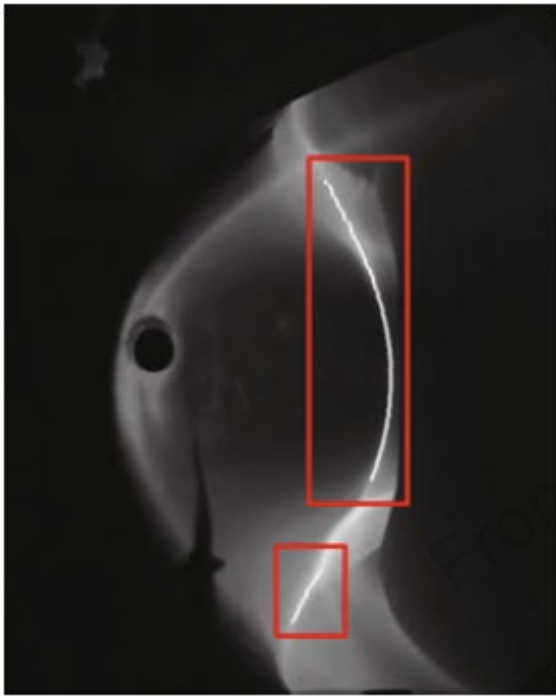


Fig. 10 Global optimization reconstruction results with horizontal drift correction

Plasma boundary reconstruction

Conclusions

1. We have described the EAST Tokamak optical plasma boundary reconstruction including plasma boundary detection and plasma boundary reconstruction.
2. We have proposed a plasma boundary detection method based on global contrast, which shows high robustness.
3. Without camera calibration, we have proposed a plasma boundary reconstruction model based on the least squares method to transform the extracted boundary from the image plane to the Tokamak poloidal plane.