Computer vision-based framework for extracting geological lineaments from optical remote sensing data

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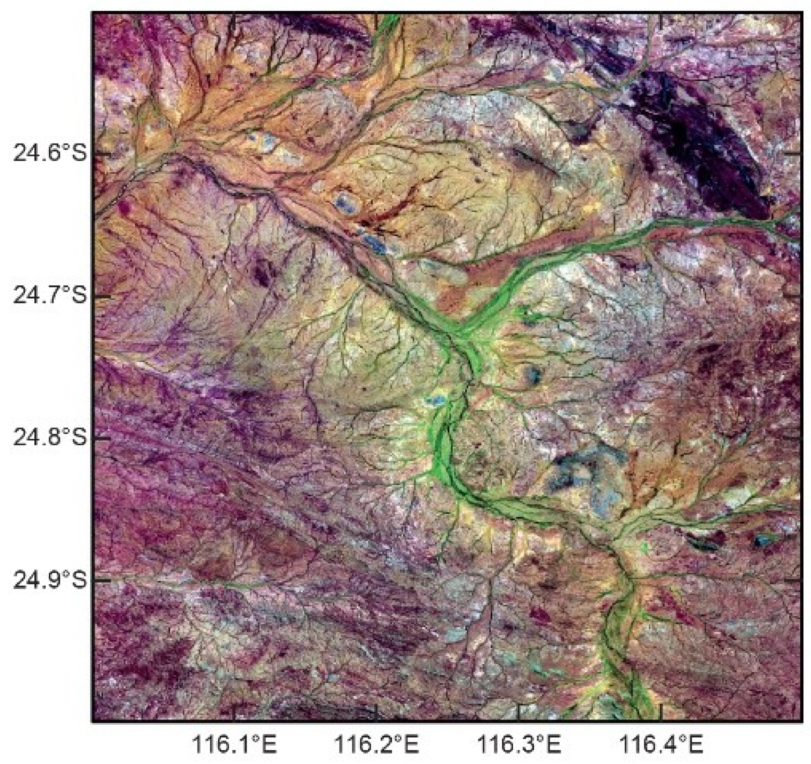
Abstract

We present a framework for extracting geological lineaments using computer vision techniques. The proposed framework is a combination of edge detection and line extraction algorithms for extracting geological lineaments using optical remote sensing data. It features ancillary computer vision techniques for reducing data dimensionality, removing noise and enhancing the expression of lineaments. The efficiency of three dimension reduction techniques and two convolutional filters are compared in terms of enhancing the lineaments. We test the proposed framework on Landsat 8 data of a mineral-rich portion of the Gascoyne Province in Western Australia. To validate the results, the extracted lineaments are compared to our manual photointerpretation and geologically mapped structures by the Geological Survey of Western Australia (GSWA).



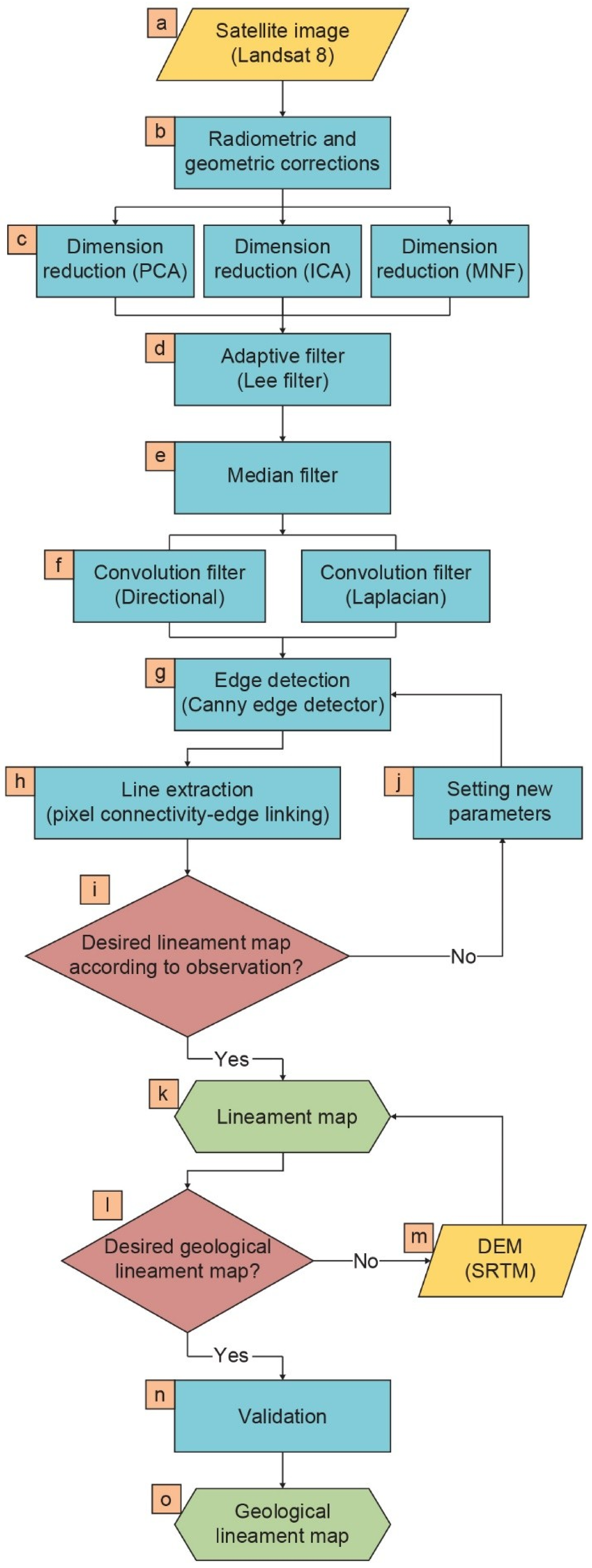


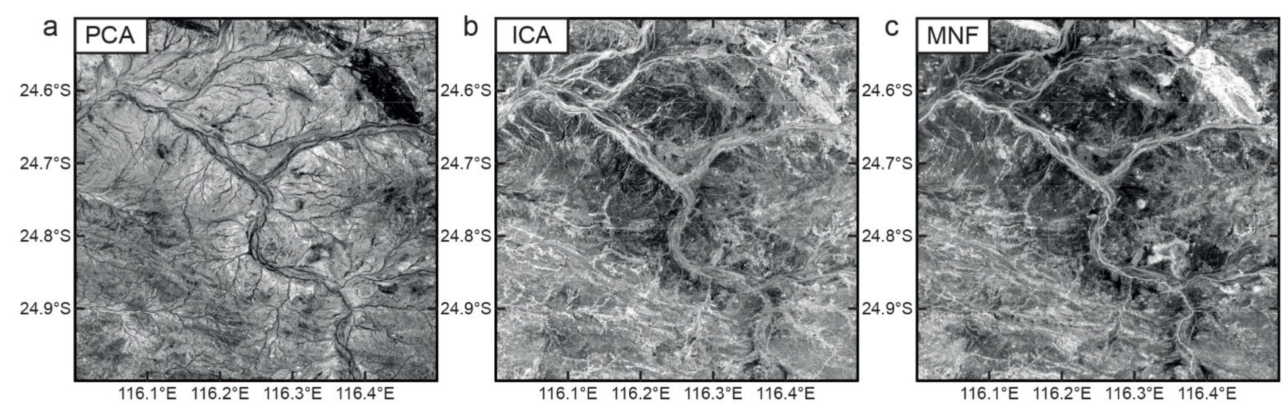
Fig. 1 Methodology flowchart of this study for semi-automatic extraction of geological lineaments.

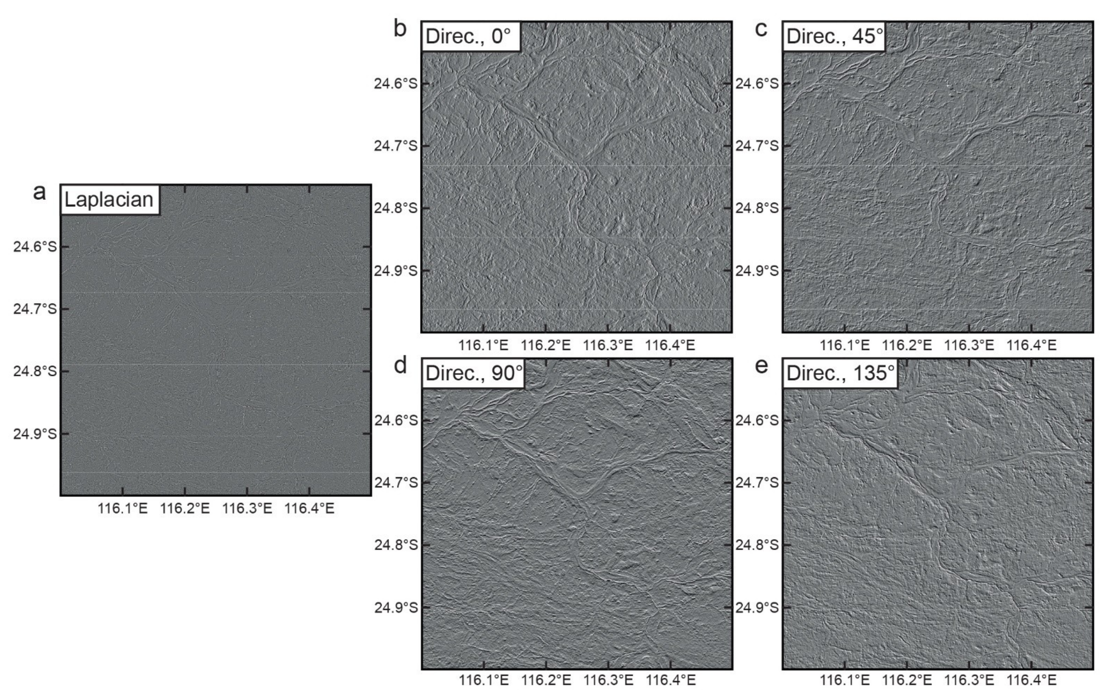
Introduction

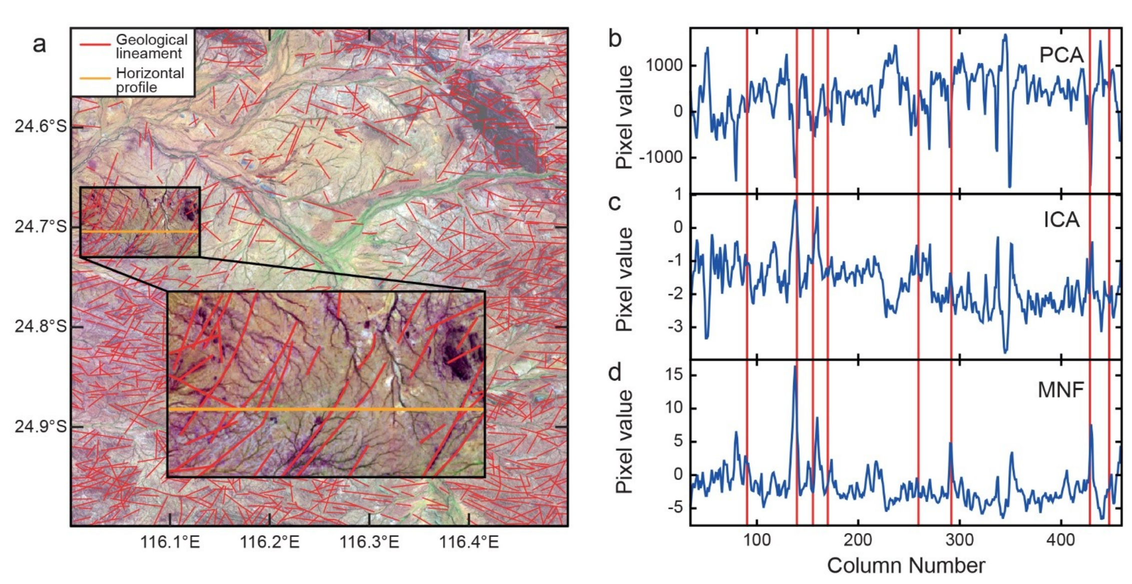
A linear feature is a two-dimensional, straight or slightly curved line, linear pattern or alignment of discontinuous patterns evident in an image, photo or map [1]. Specific physiographic characteristics of a linear feature make it possible to detect them due to the tonal change in digital satellite data [2]. Geological lineaments are an expression of the underlying geological structure and include faults, dykes, shear zones and folds. Linear to curvilinear faults, dykes and shear zones are of particular interest in assisting mineral prospecting because of their association with hydrothermal mineralization [3]. Although manual interpretation is effective at identifying geological lineaments [4], computer vision techniques are required to make this process efficient. Computer vision is an interdisciplinary field that employs a wide range of algorithms for gaining a high-level understanding from digital images or videos [5]. Traditionally, lineament mapping is based on a visual or manual photointerpretation. Manual digitizing of lineaments is subjective, time consuming and expensive [6].

Materials and Methods

We use a cloud-free Landsat 8 OLI level-2 data product (surface reflectance) to test our framework. To validate the proposed semi-automated workflow (Fig. 1), different maps including a structural geological map provided by the GSWA and a geological lineament map obtained from manual photointerpretation are used (Fig. 2). Edge detection is performed using a Canny edge detector and lines are then extracted from the binary image produced by the Canny edge detection process using pixel connectivity-edge linking. According to the spatial resolution of the OLI imagery, streams are the most important cultural linear features which can be mistaken for geological linear features. Here, we used Shuttle Radar Topography Mission (SRTM) data with a spatial resolution of 30 m to delineate streams.







Comparison of dimension reduction techniques through extracting geological lineaments using a horizontal profile

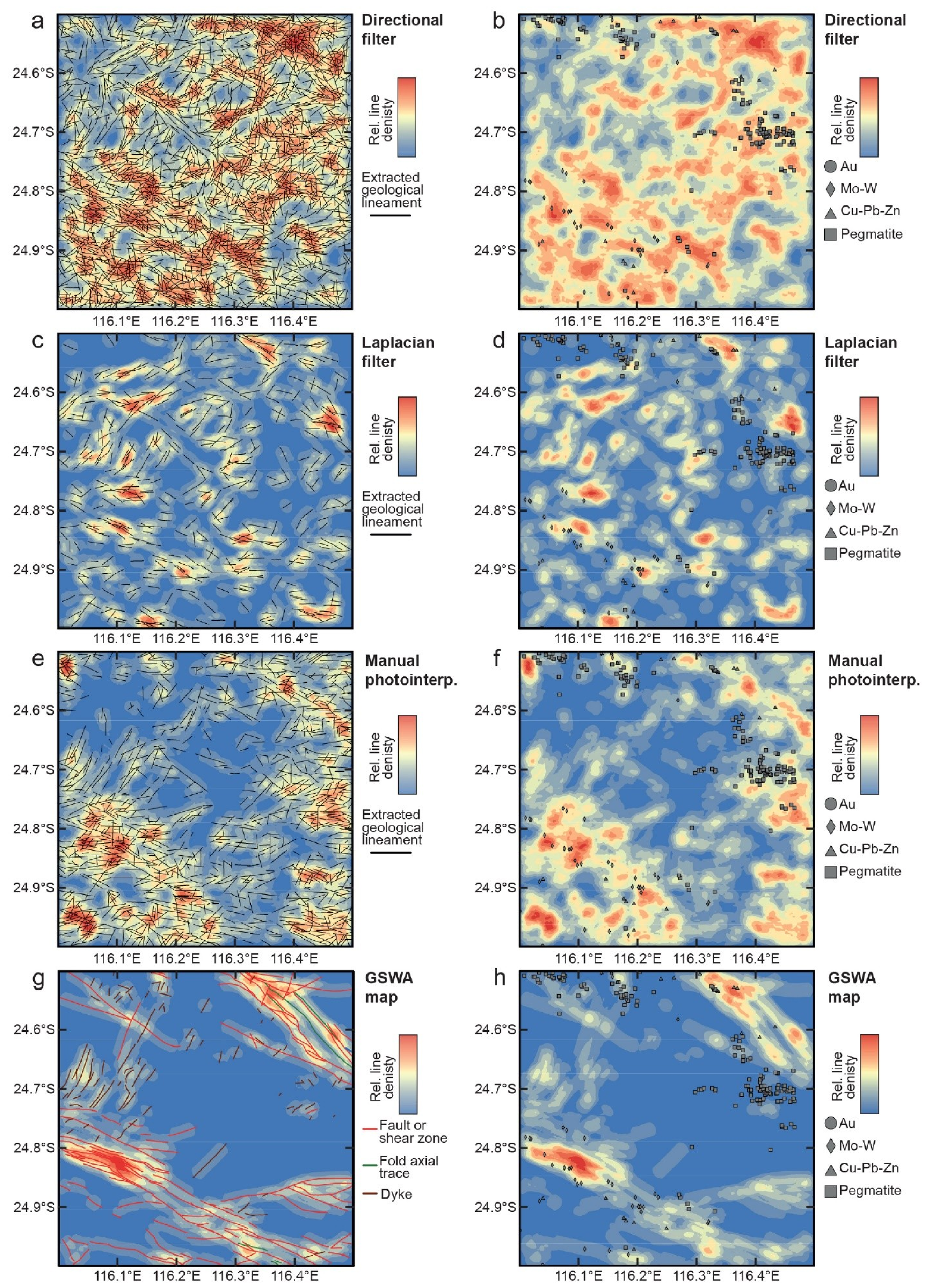


Fig. 2 Superposition of geological lineaments and hydrothermal mineral occurrences on density maps obtained from the proposed framework and traditional maps.

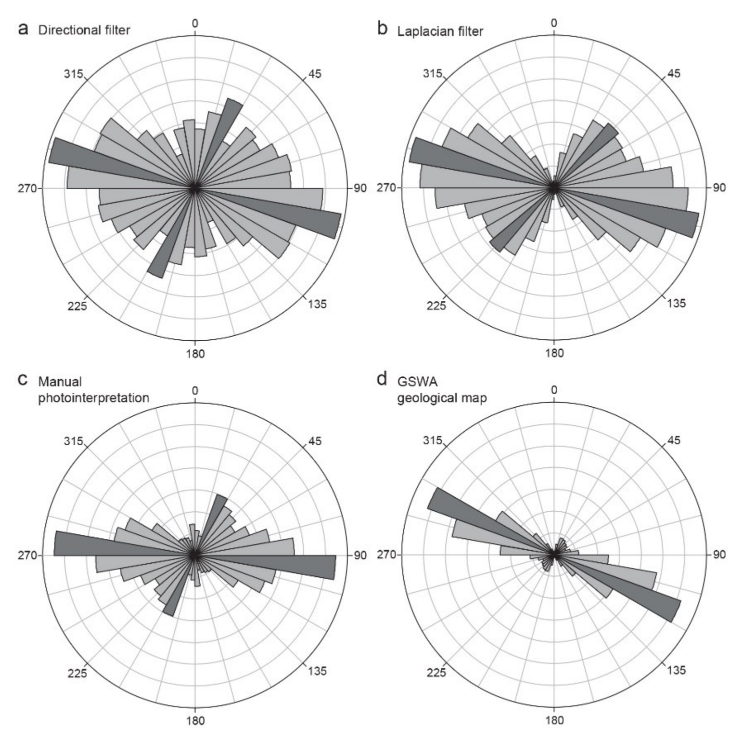
Discussion

The results show that the best correlation between our extracted geological lineaments and the GSWA geological lineament map is achieved by applying a minimum noise fraction transformation and a Laplacian filter. Application of a directional filter instead shows a stronger correlation with the output of our manual photointerpretation and known sites of hydrothermal mineralization. Hence, our method using either filter can be used for mineral prospectivity mapping in other regions where faults are exposed and observable in Landsat 8 data.

Geological lineament maps provided by field observations are biased by the mapping geologist, who may have different views in dealing with the same structural features. The proposed framework is significantly less biased by the operator, but it is possible to modify the final map by applying new parameters to approach the desired geological lineament map.

Conclusion

The comparison of different dimension reduction techniques shows that the extracted geological lineaments using the output component of the MNF technique are best correlated with the available geological lineament map provided by the manual photointerpretation. We conclude that the geological lineaments which are extracted using a directional filter are highly correlated with the hydrothermal mineral occurrences, even more than the map provided by the manual photointerpretation.



Download the preprint: https://arxiv.org/abs/1810.02320
Download the codes: https://github.com/intelligent-exploration/IP_MinEx

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