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

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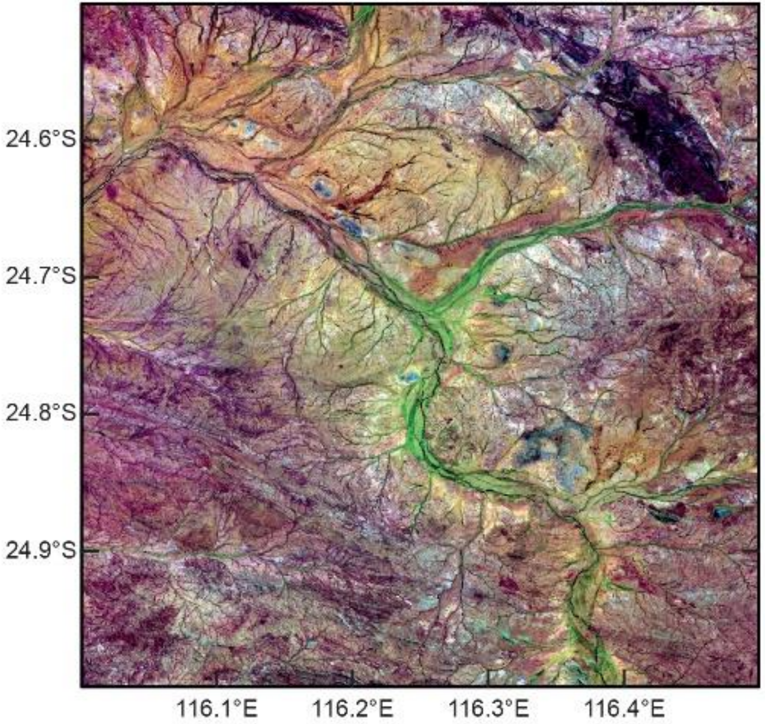

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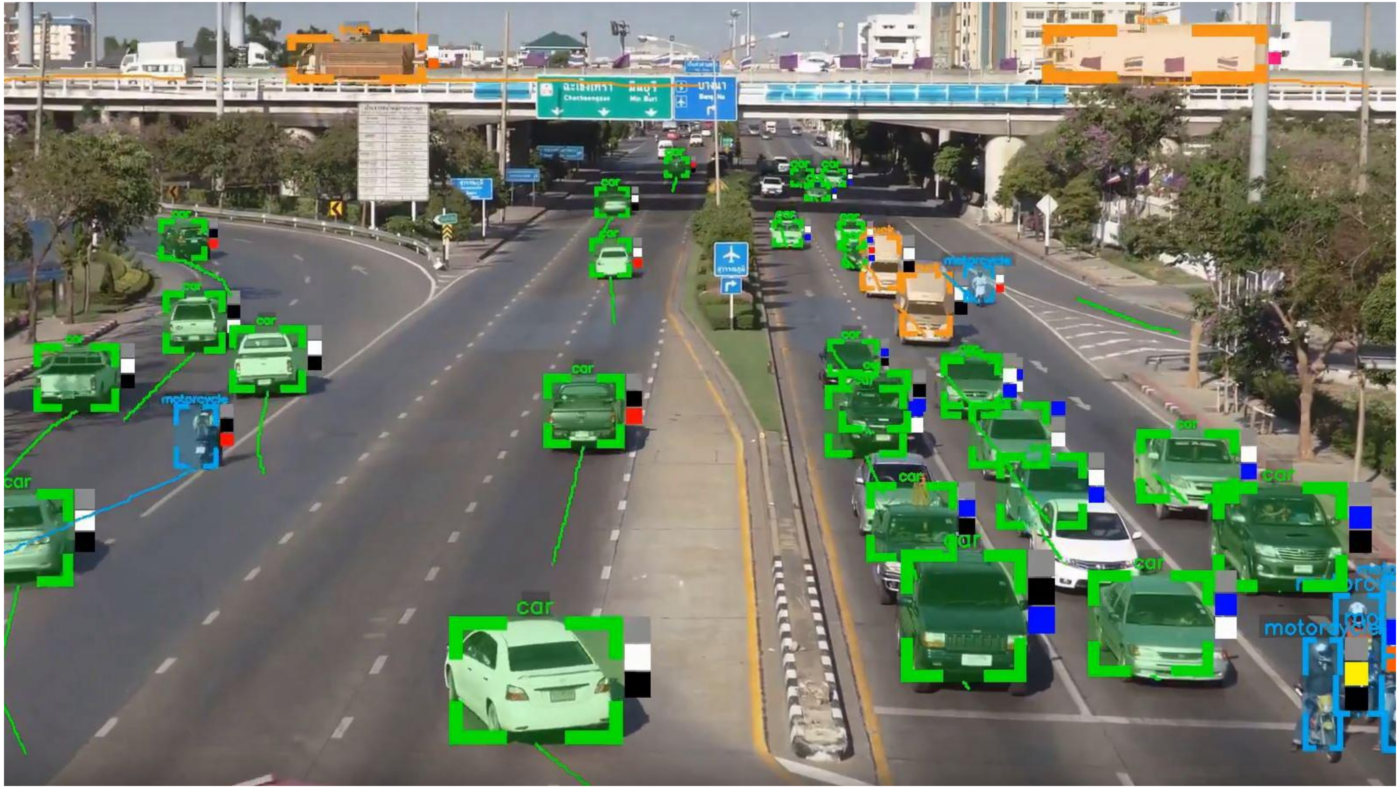
Ehsan Farahbakhsh, Hugo K. H. Olierook, Richard Scalzo, Steven Reddy, Christopher Clark, R. Dietmar Müller

Computer vision - tracking



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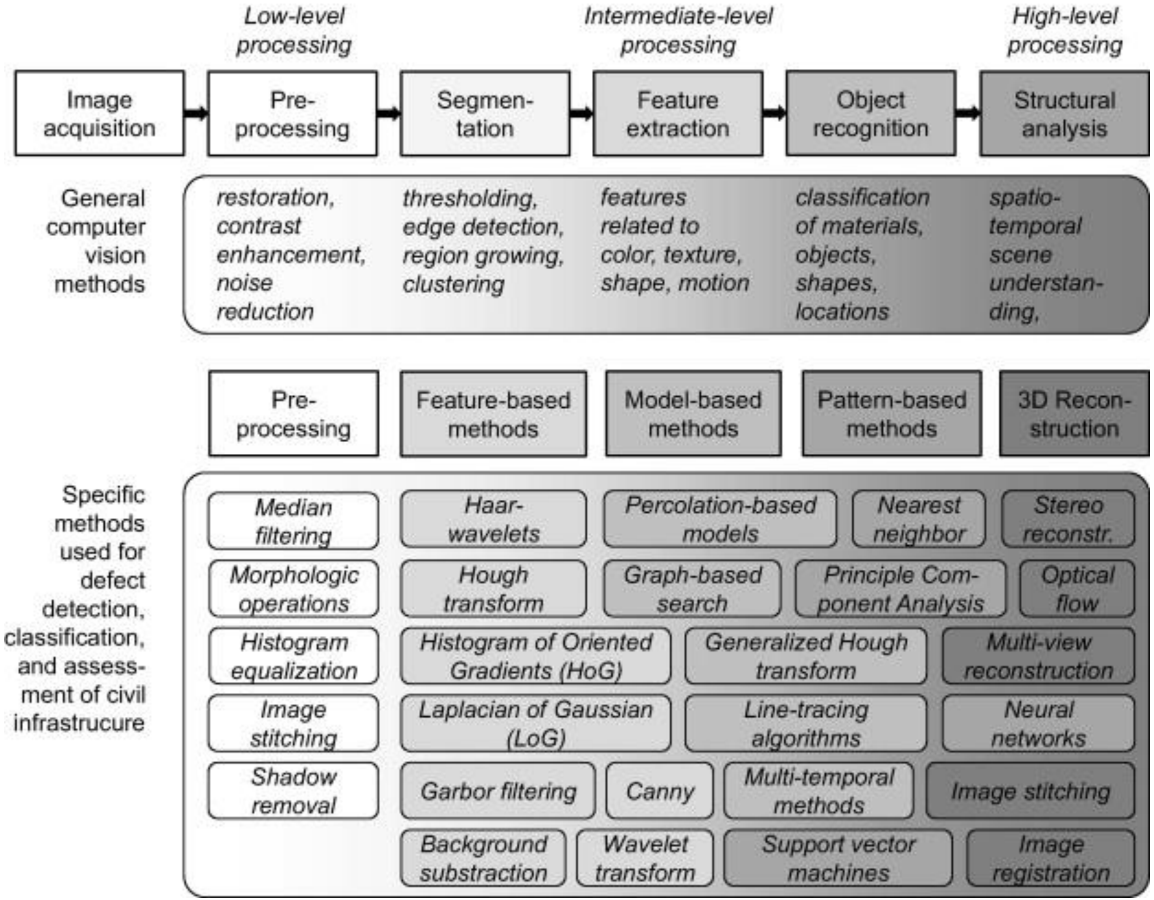
Edge detection

CV Methods



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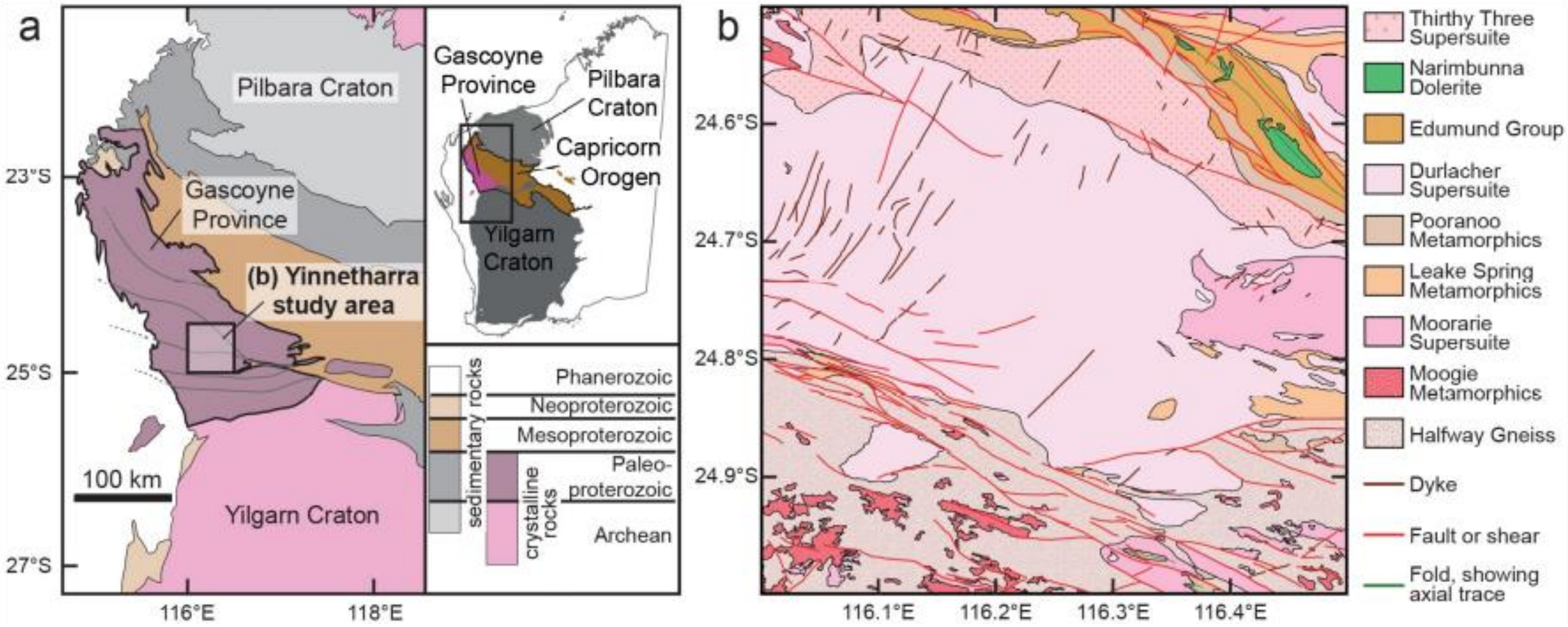
Motivation and Scope

The location of geological lineaments such as faults and dykes are of interest for a range of applications, particularly because of their association with hydrothermal mineralization.

Although a wide range of applications have utilized computer vision techniques, a standard workflow for application of these techniques to mineral exploration is lacking.

We present a framework for extracting geological lineaments using computer vision techniques.

Study Area



a
Pilbara Craton
Gascoyne Province
(b) Yinnetharra study area
100 km
Yilgarn Craton
23°S
25°S
27°S
116°E
118°E
Gascoyne Province
Pilbara Craton
Capricorn Orogen
Yilgarn Craton
sedimentary rocks
crystalline rocks
Phanerozoic
Neoproterozoic
Mesoproterozoic
Paleo-proterozoic
Archean
b
24.6°S
24.7°S
24.8°S
24.9°S
116.1°E
116.2°E
116.3°E
116.4°E
Thirthy Three Supersuite
Narimbunna Dolerite
Edumund Group
Durlacher Supersuite
Pooranoo Metamorphics
Leake Spring Metamorphics
Moorarie Supersuite
Moogie Metamorphics
Halfway Gneiss
Dyke
Fault or shear
Fold, showing axial trace

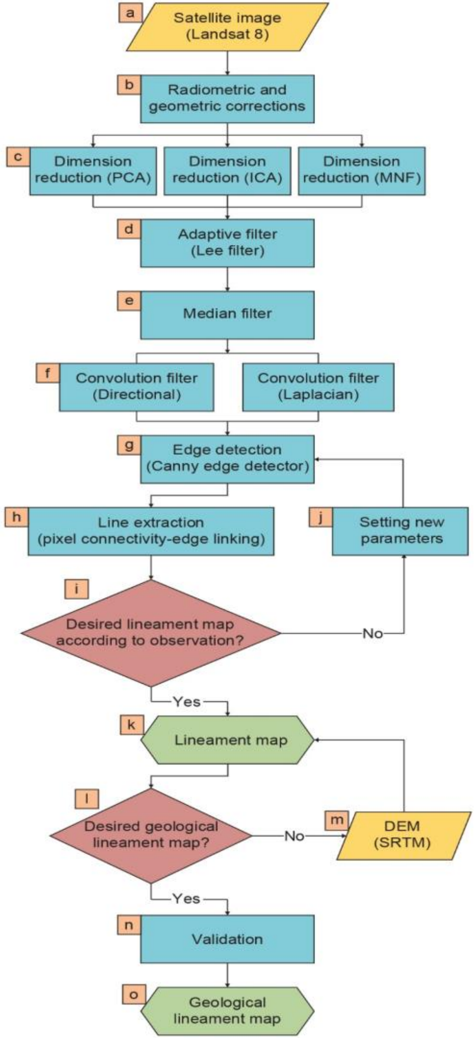
Materials and Methods

We use a cloud-free Landsat 8 OLI level-2 data product (surface reflectance) to test our framework.

Map provided by the Geological Survey of Western Australia (GSWA)

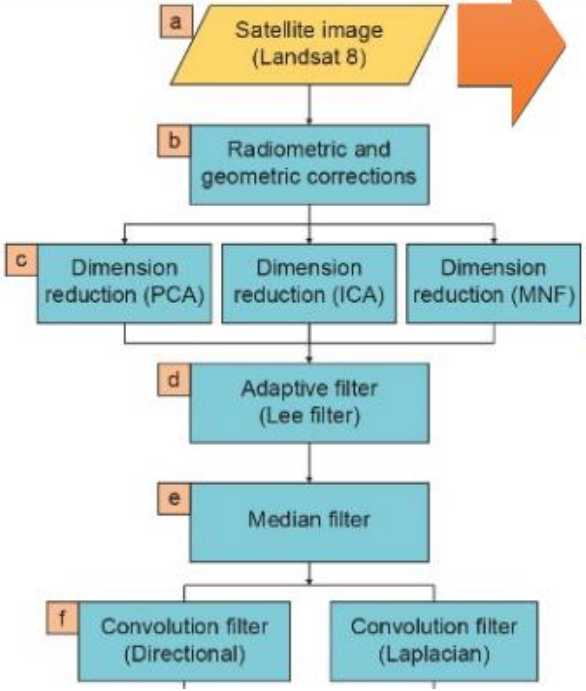
Edge detection is performed using a Canny edge detector

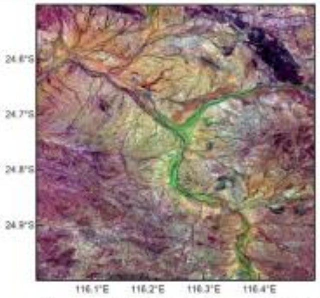
We used Shuttle Radar Topography Mission (SRTM) data with a spatial resolution of 30 m to delineate streams.

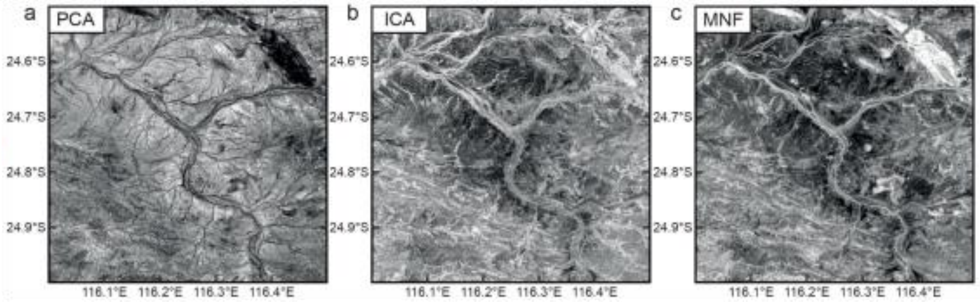


CV Framework for exploration

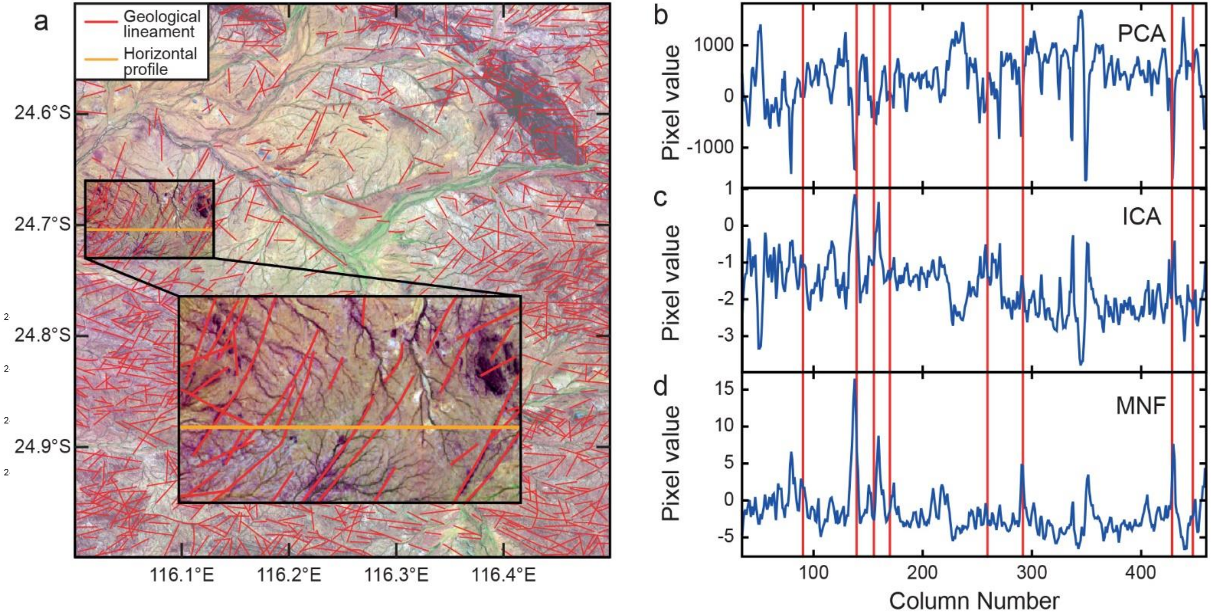
Framework


a
Satellite image (Landsat 8)
b
Radiometric and geometric corrections
c
Dimension reduction (PCA)
Dimension reduction (ICA)
Dimension reduction (MNF)
d
Adaptive filter (Lee filter)
e
Median filter
f
Convolution filter (Directional)
Convolution filter (Laplacian)

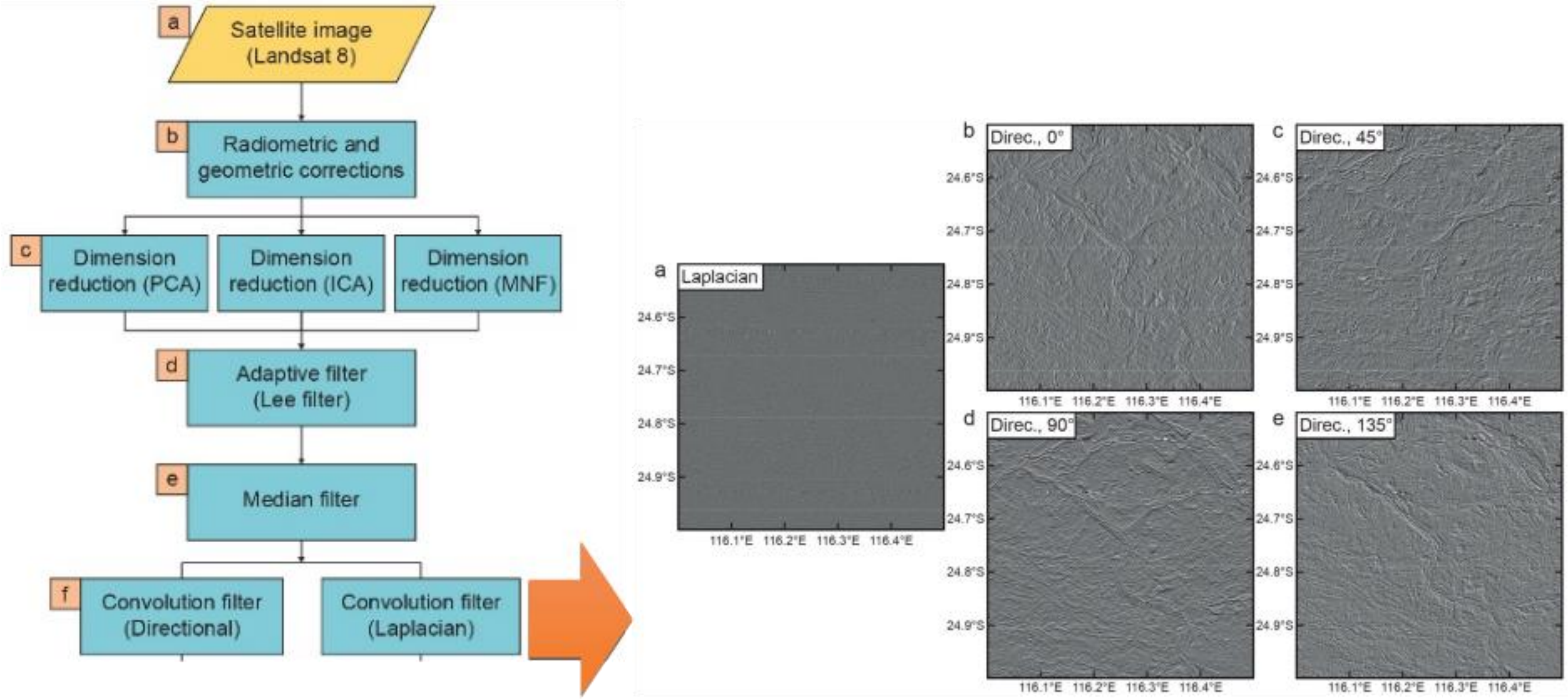


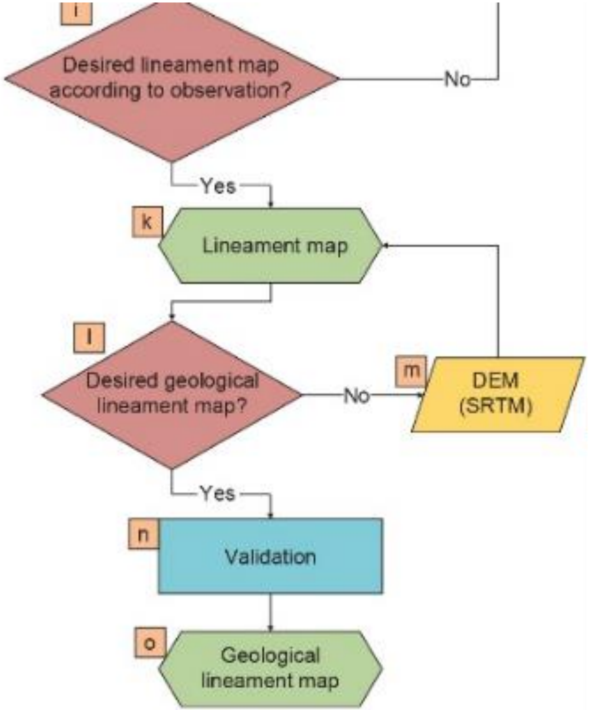

a
PCA
b
ICA
c
MNF
24.6°S
24.7°S
24.8°S
24.9°S
116.1°E
116.2°E
116.3°E
116.4°E

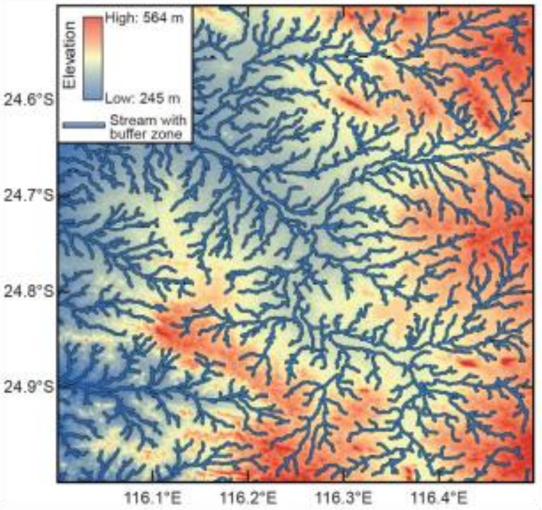
Comparison of the different dimension reduction techniques with manual photointerpretation shows that the MNF component is more robust than the PCA and ICA components for extracting geological lineaments



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

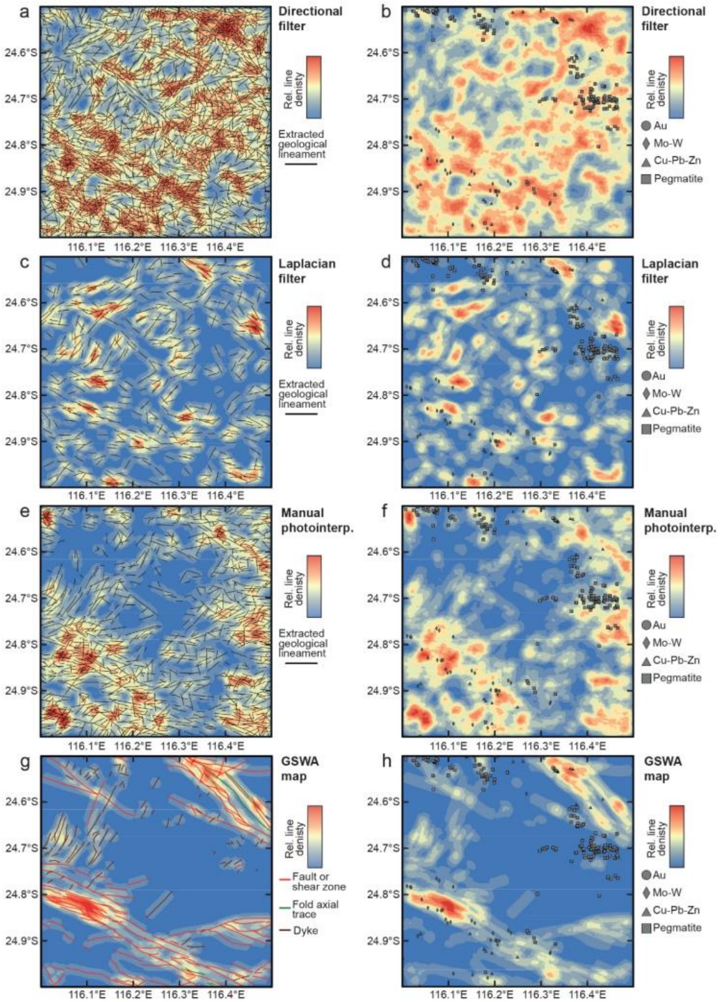

a
Satellite image
(Landsat 8)
b
Radiometric and
geometric corrections
c
Dimension
reduction (PCA)
Dimension
reduction (ICA)
Dimension
reduction (MNF)
d
Adaptive filter
(Lee filter)
e
Median filter
f
Convolution filter
(Directional)
Convolution filter
(Laplacian)
a
Laplacian
b
Direc., 0°
c
Direc., 45°
d
Direc., 90°
e
Direc., 135°
24.6°S
24.7°S
24.8°S
24.9°S
116.1°E
116.2°E
116.3°E
116.4°E


j
Desired lineament map according to observation?
No
Yes
k
Lineament map
l
Desired geological lineament map?
No
m
DEM (SRTM)
Yes
n
Validation
o
Geological lineament map

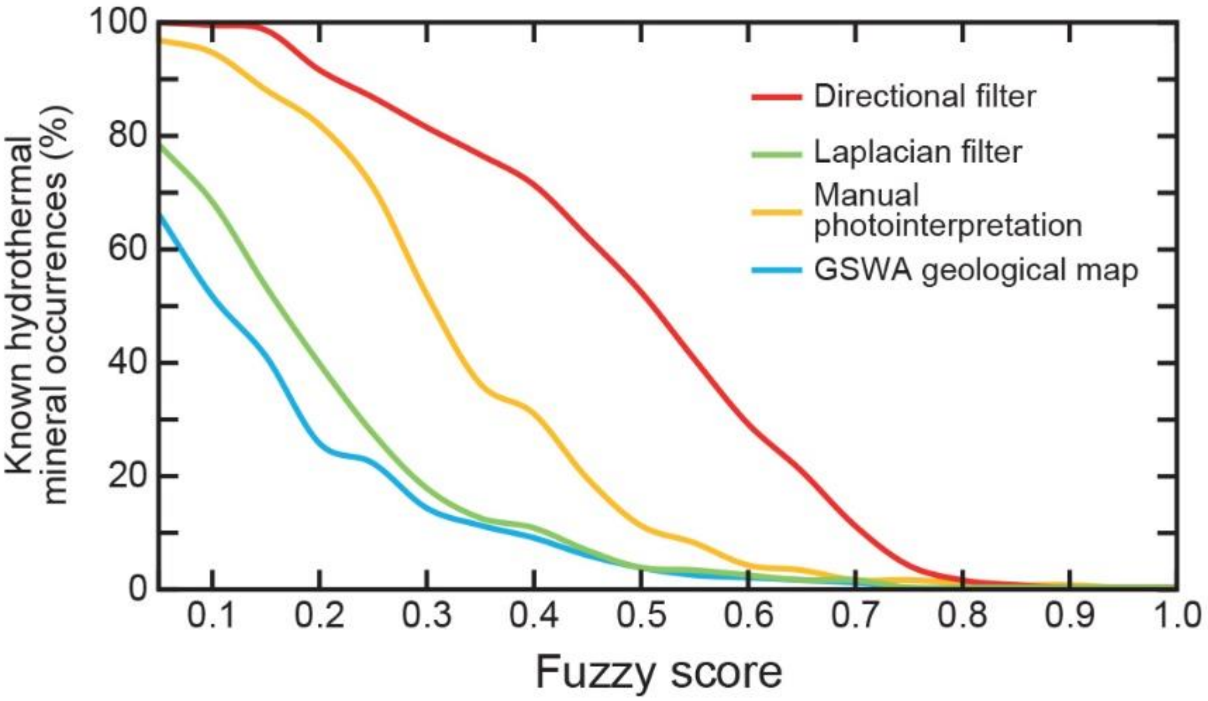

Elevation
High: 564 m
Low: 245 m
Stream with buffer zone
24.6°S
24.7°S
24.8°S
24.9°S
116.1°E
116.2°E
116.3°E
116.4°E

Density Maps

Superposition of **geological lineaments** and **hydrothermal mineral occurrences** on density maps resulted from the proposed framework using the MNF component improved by the a, b) **directional** and c, d) **Laplacian filters**; e, f) geological lineaments mapped by the **manual photointerpretation** and g, h) the **GSWA**.



Spatial association between hydrothermal mineral occurrences and different geological lineament density maps. Lineament density values are taken into fuzzy space using a linear function.

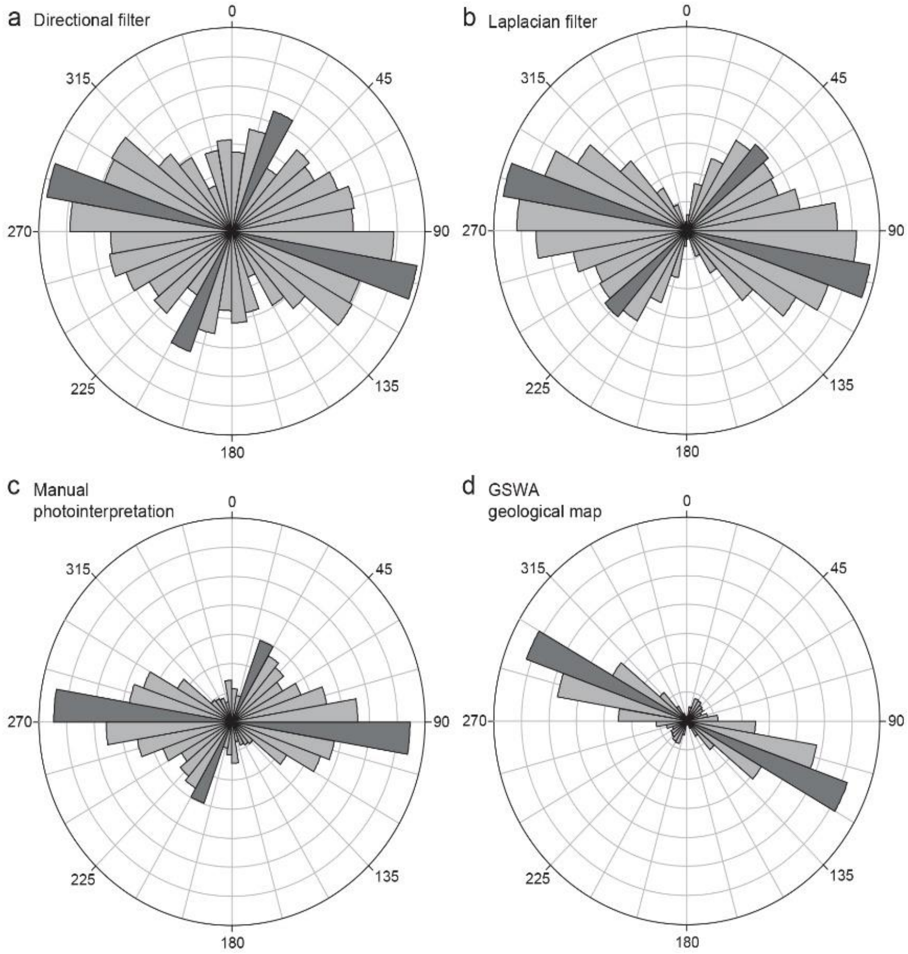


The x axis shows the fuzzy thresholds from 0 to 1. The y axis shows the percentage of known hydrothermal mineral occurrences that are placed in anomalous areas according to the thresholds shown in x axis.

Validation

Rose diagrams showing the number and orientation of the geological lineaments extracted by the proposed framework using a) **directional** and b) **Laplacian filters** applied on the MNF component.

Rose diagrams of the geological lineaments mapped by c) **manual photointerpretation** and d) the **GSWA** are also shown.



Future work

- Fusion of data from various maps (Gravity and Magnetics)
- Uncertainty quantification in edge detection (Bayesian or Frequentist ?)
- Uncertainty quantification for free parameters in the framework (eg. parameters in Canny edge detection)
- Machine learning methods for prediction of geological structures – topology
- Applications in other regions

Questions welcome

Technical Report: Ehsan Farahbakhsh, Rohitash Chandra, Hugo K. H. Olierook, Richard Scalzo, Chris Clark, Steven M. Reddy, R. Dietmar Muller: "Computer vision-based framework for extracting geological lineaments from optical remote sensing data", https://arxiv.org/abs/1810.02320

Github: https://github.com/intelligent-exploration/IP_MinEx

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