DLR

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TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

Artificial Intelligence for SAR Quality Control

ICEYE

João G. Vinholi
ML Engineer

ESA UNCLASSIFIED – For ESA Official Use Only

UNMATCHED PERSISTENT MONITORING CAPABILITIES

WITH THE WORLD'S LARGEST SAR CONSTELLATION

2012

ICEYE LAUNCHED

3400+

SAR IMAGES **ANALYSED TO DATE**

16

SAR **SATELLITES**

HEADQUARTERS IN FINLAND

PRESENCE IN: POLAND, US, SPAIN, LUXEMBOURG, & UK

WORLD LEADER

IN SYNTHETIC APERTURE RADAR (SAR) MINIATURIZATION TECHNOLOGY

CUSTOMERS INCLUDE **European Space Agency, European Maritime Security Agency**

ICEYE

Frequent Problems in SAR Data

Image Artifacts

- Speckle
- Ambiguities
- RF Interference
- DFT Side Lobes

+

Geolocation Errors

- Image Defocusing
- Coregistration Problems
- Bad Orthorectification

Image Artifacts

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Azimuth Ambiguities

The ambiguities were generated by the secondary lobes of the azimuth antenna pattern

Corrected Image

Range Ambiguities

Left: The image is strongly impared by range ambiguities, that resemble transparent copies of the upper features.

Right: Corrected image.

Geolocation Errors

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Geolocation Errors

Available at: https://www.iceye.com/lp/example-strip-sar-dataset-acre-brazil

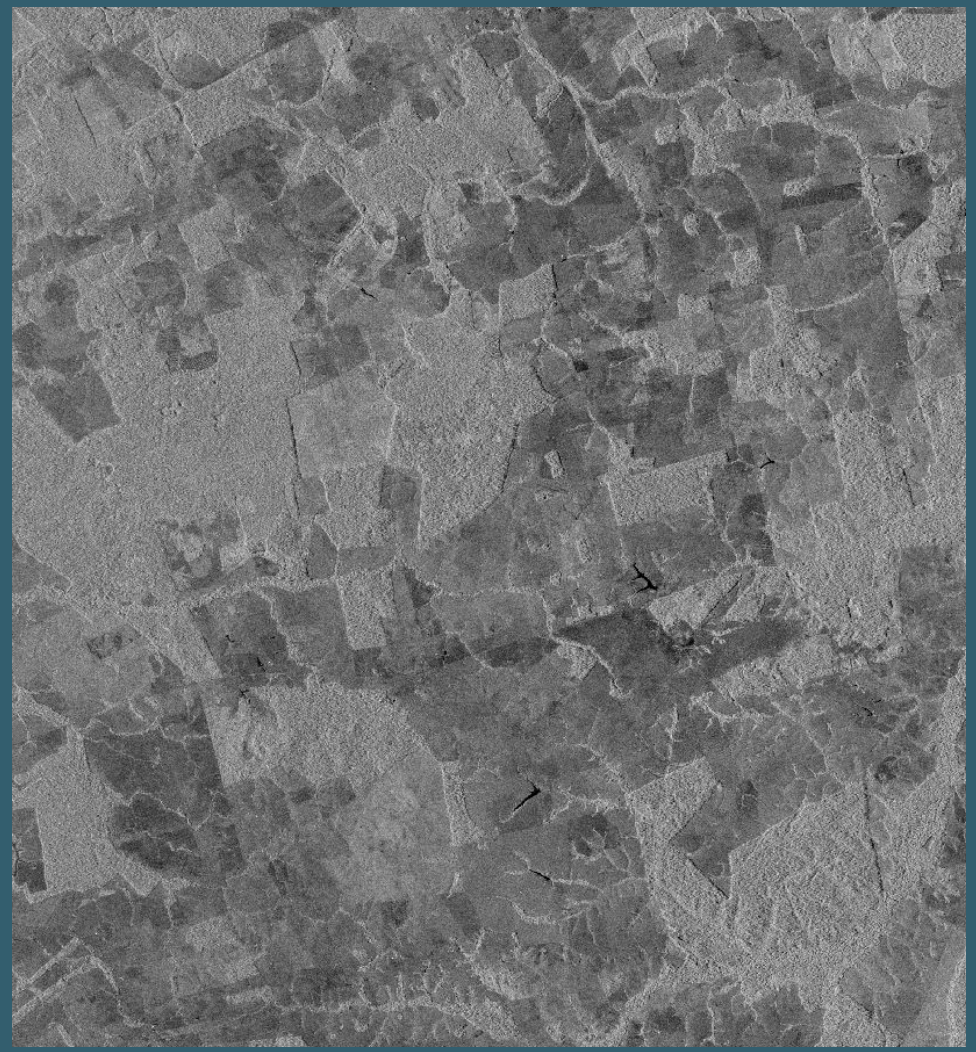


Image synthesized with correct geolocation info.

Image synthesized with wrong geolocation info.

Geolocation Errors

Stacking of SAR Images Can Be Severely Impared by Geolocation Errors

Targets in both images are overlapping in the difference image, despite not being in the same spatial location.

Trying to detect the targets in the first image by change detection is impossible, as both images cancel out in this spot.

Images publicly available at:
https://www.sdms.afrl.af.mil/index.php
CARABAS-II Dataset

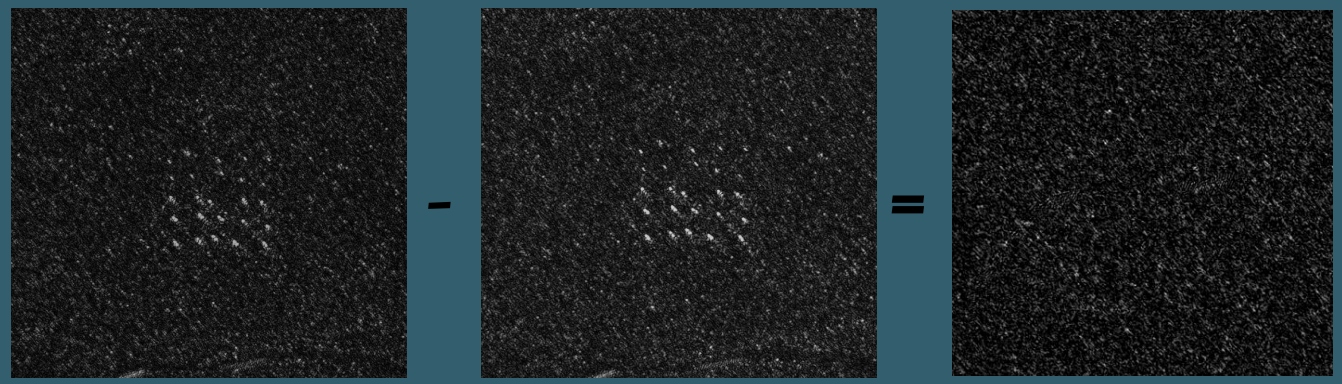
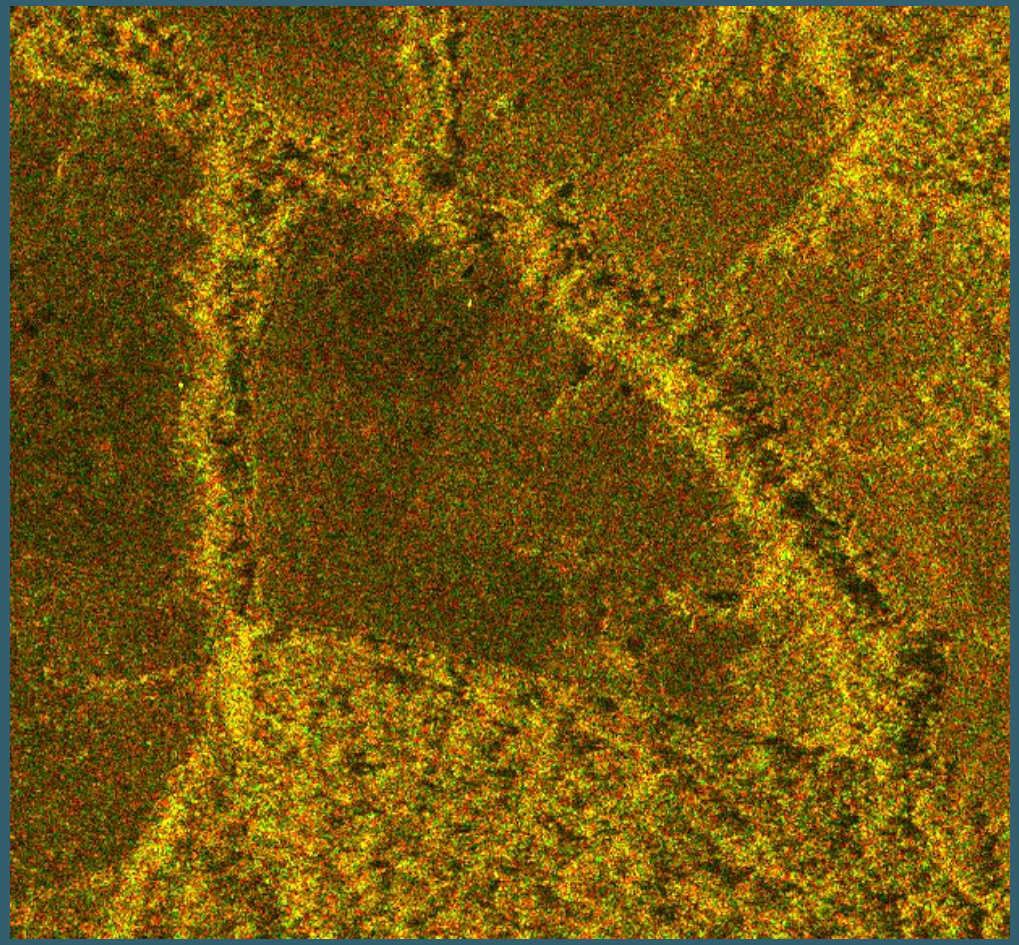
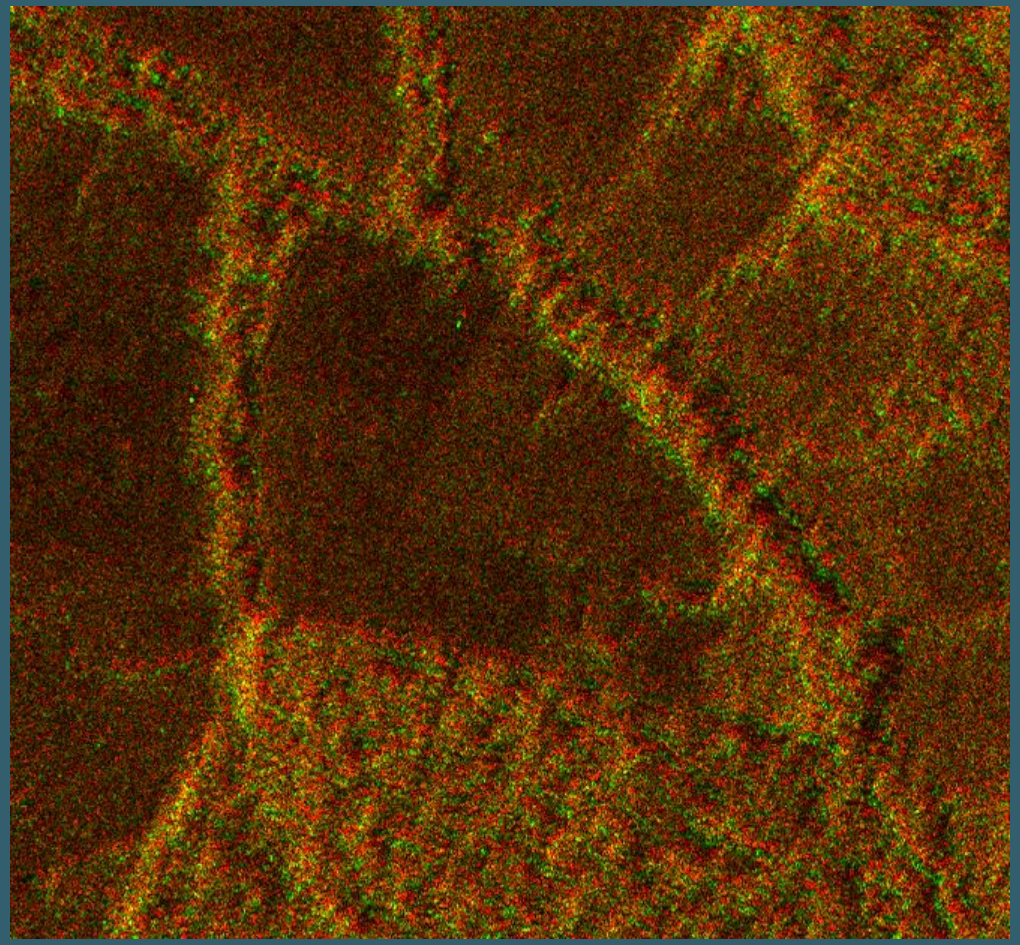


Image 1 – Image 2 (Bad Geolocation) = Difference Image

Geolocation Errors → Bad Coregistration

Available at:
https://medium.com/iceye-analytics/spatially-align-a-time-series-stack-of-iceye-sar-images-with-a-dockerized-esa-snap-routine-51a895a4a739 - Courtesy of Arnaud Dupeyrat
For the full images: https://www.iceye.com/lp/example-strip-sar-dataset-acre-brazil





Coregistration of EO Images with Incorrectly Geolocated Images

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Why AI for Coregistration?

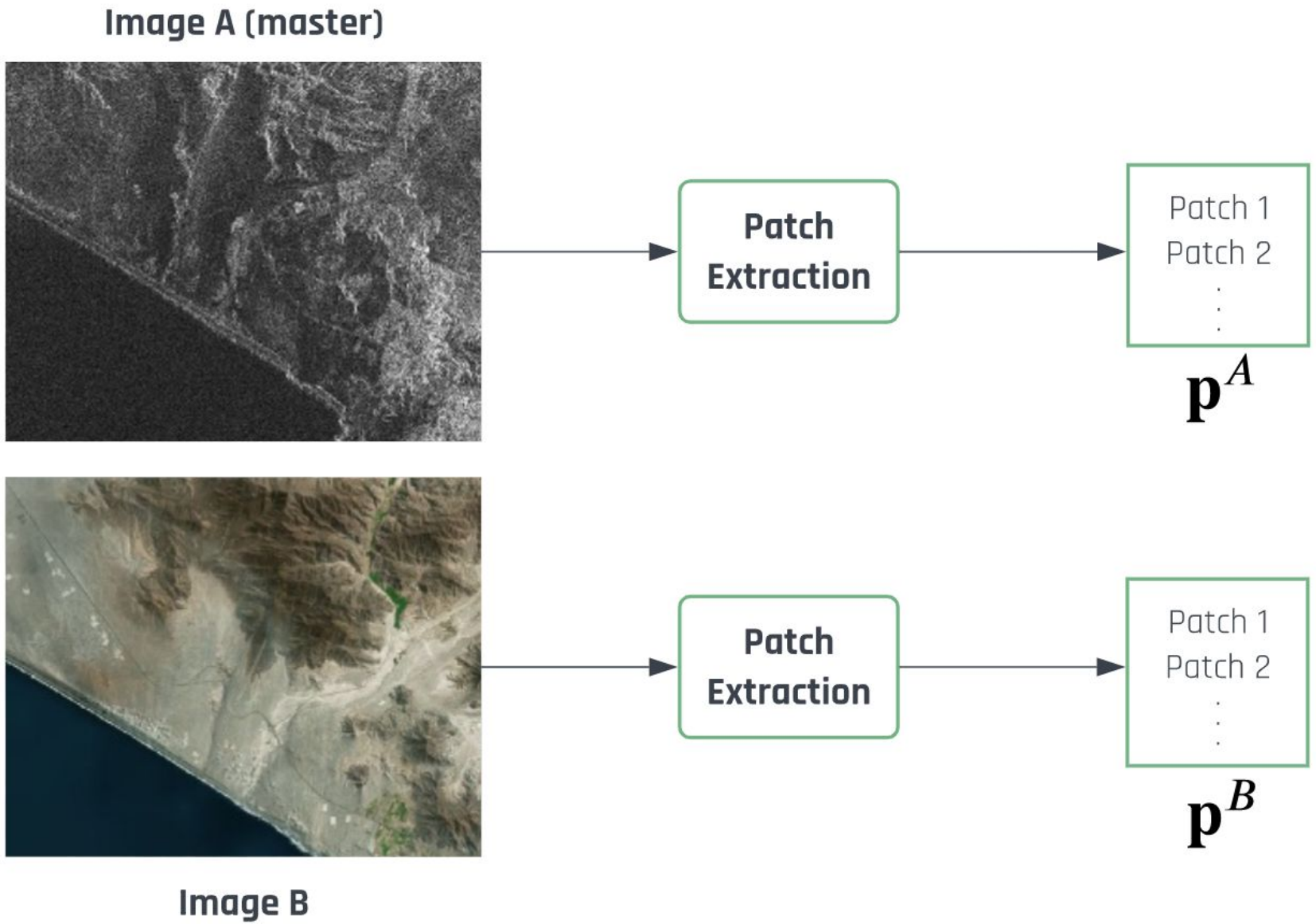
- Traditional coregistration algorithms are **often not robust enough** to coregister images from **different data domains**.
  - SAR to SAR from different sensors.
  - SAR to optical data.
  - Optical to LIDAR data.

- Some image pairs present **distortions and shifts** between themselves, caused by multiple possible factors: different projections, bad elevation data for orthorectification, etc. Traditional algorithms **are not robust enough** to this combination.

- Deep learning-based solutions have shown for a decade their capacity of identifying complex patterns in data.

Data Preparation

Image A available at:
https://www.iceye.com/lp/example-strip-dataset-peru-oil-spill
Image B obtained from Bing Maps



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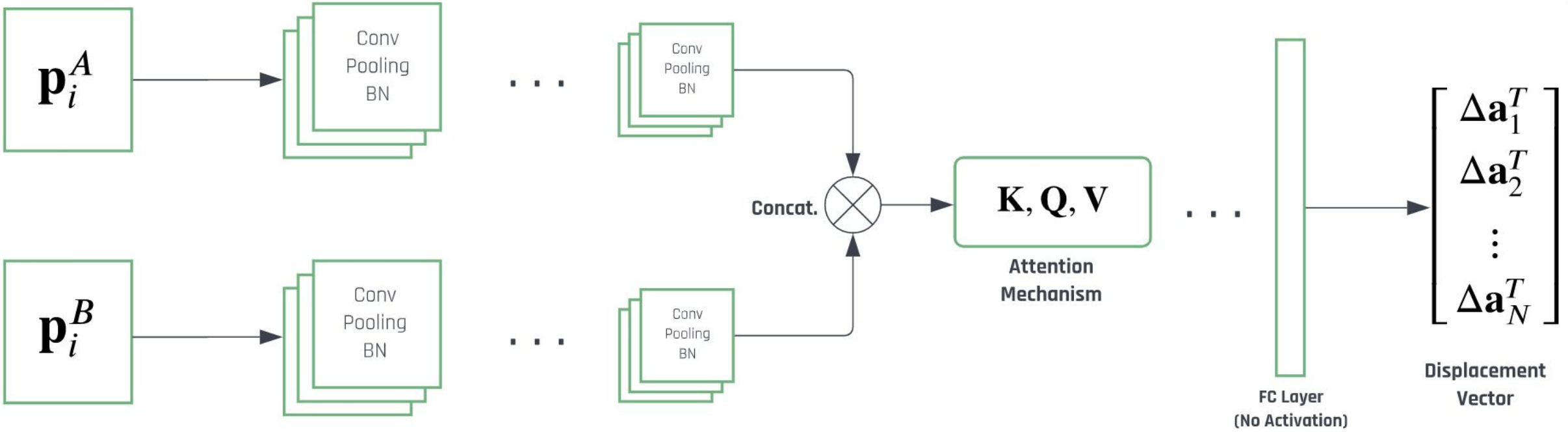
Proposed Architecture

Inspired by:

Remote Sensing Image Registration Based on Deep Learning Regression Model. Li, et al. IEEE GRSL, 2022.

$$\Delta \mathbf{a}_j = \left[\Delta x_j, \Delta y_j\right],\ j \in \{1, 2, \cdots, N\}$$
$$\Delta x_j = x'_j - x_j$$
$$\Delta y_j = y'_j - y_j$$



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