Neural network prediction of model parameters for strong lenses from HSC

Gawade et al. 2024 (arXiv:2404.18897)

Priyanka Gawade (PhD student, IUCAA)

Supervisor: Surhud More

Co-Supervisor: Anupreeta More

Collaborators : Akisato Kimura, Alessandro Sonnenfeld, Masamune Oguri, Naoki Yoshida
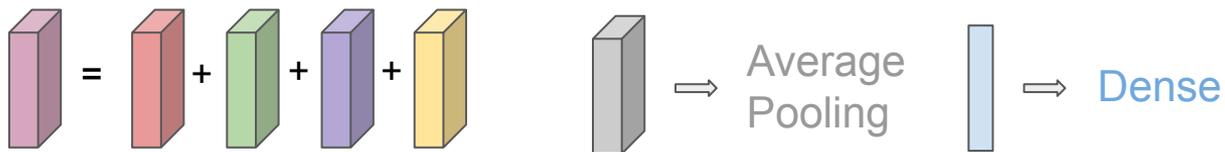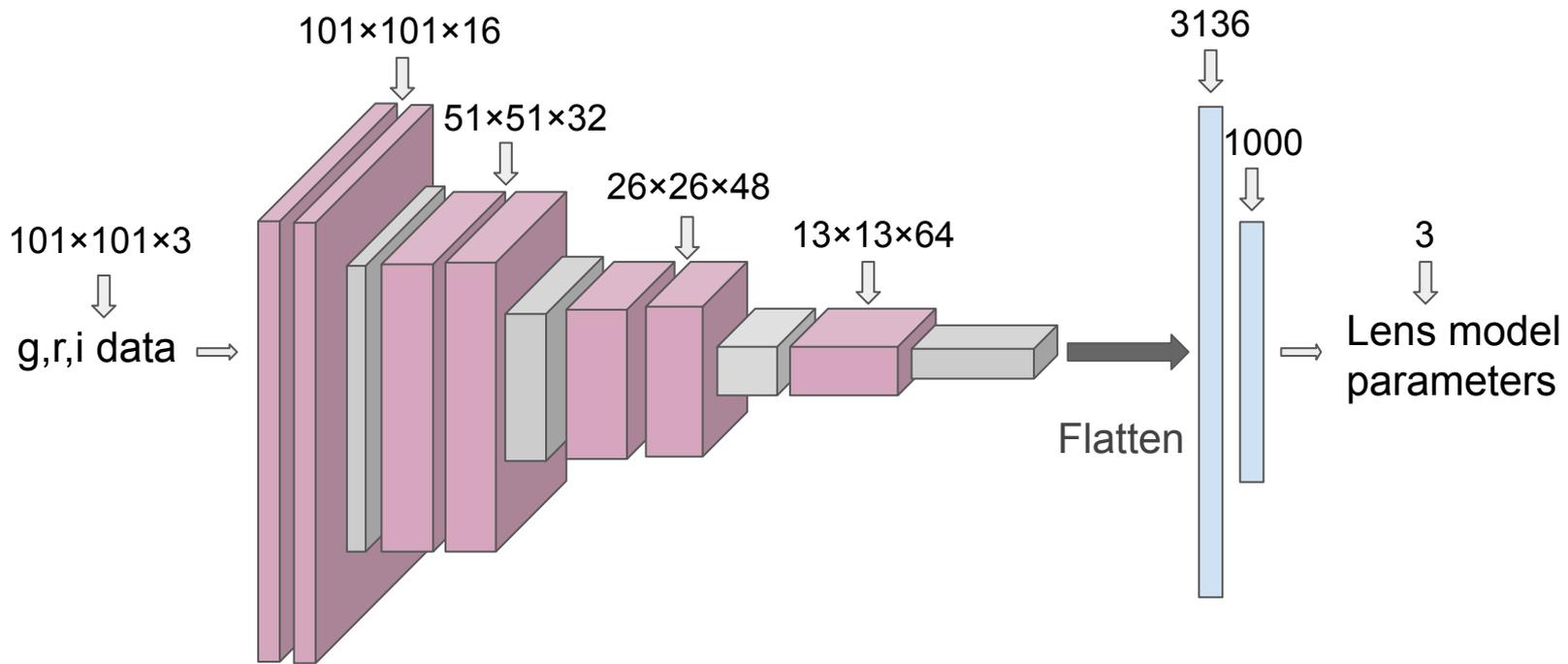
Motivation and Goals

- Survey like SuGOHI has already produced a few hundreds of images of lensed systems and this number is going to increase by at least a couple of order of magnitude with the advanced upcoming ground based surveys like LSST

- Conventional lens modelling methods: time and resource consuming

- We aim to build a neural network that will enable us to rapidly analyse the images of lens systems taken from ground based telescope surveys such as HSC and LSST (motivated by Hezaveh et al., Nature 2017, high quality space based images from HST)

- Analysing images from ground based telescopes is challenging :
  - poor image quality is due to atmospheric seeing and
  - low pixel resolution compared to the space telescope images

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Training Data

- Images of strongly lensed galaxy-galaxy systems were simulated using SIMCT pipeline (https://github.com/anumore/simct , More et al. 2016)

- We generate images of the lensed galaxy only (i.e no lens light or any other line-of-sight features)
  - Lens model (SIE) is based on parameters of real HSC galaxies
  - Image properties are matched to the HSC image quality, depth and resolution

- Training sample : 60k images (augmented)
  - Using unique 20k samples
  - training:validation - 90:10

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Test Data

- Simulated test sample : 2850 images

- Real test sample - SuGOHI lenses (grade A+B) : 182 lenses processed and identified as lenses by YATTALENS (YL, Sonnenfeld et al. 2018)
  - Yattalens is used for two main reasons:
    - to subtract the lens light and remove the line-of-sight objects
    - to obtain "true" lens model parameters which we used to compare our network predictions with

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101×101×16

51×51×32

26×26×48

13×13×64

3136

1000

3

Lens model parameters

101×101×3

g,r,i data ⟹

Flatten

Convolution Group = Convolution + Batch Normalization + Activation (PReLU) + Dropout

⟹ Average Pooling

⟹ Dense

Training

- Loss: Mean Squared Error (MSE) with class and sample weights.

- Optimizer: Adam (learning rate = 0.001)

- Dropout: 20%

- Batch size = 64

- Early stopping warning (monitoring validation loss)

- Hyper parameter tuning

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Analysis of different Scenarios

- Lensed galaxies (Ideal case, No bkg noise)
- Lensed galaxies + Gaussian bkg noise
- Lensed galaxies + HSC lens galaxies
- Lensed galaxies + HSC lens galaxies (after YL lens light subtraction)
- Simulated lensed galaxies added to HSC cutouts with central empty regions (Best case scenario!)
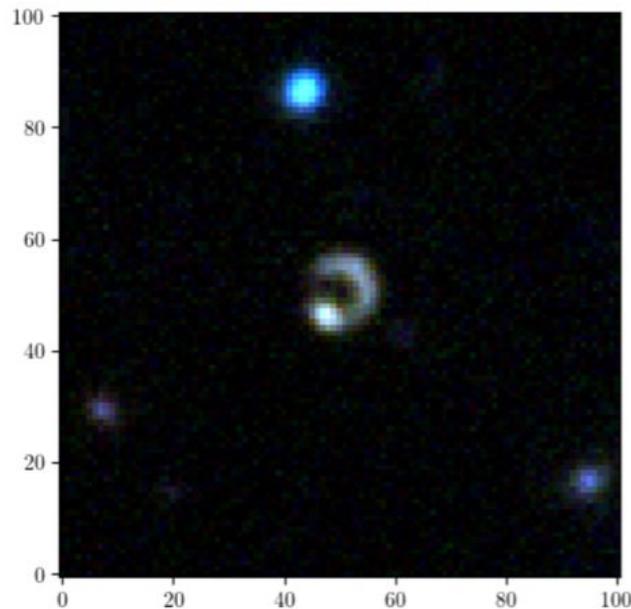
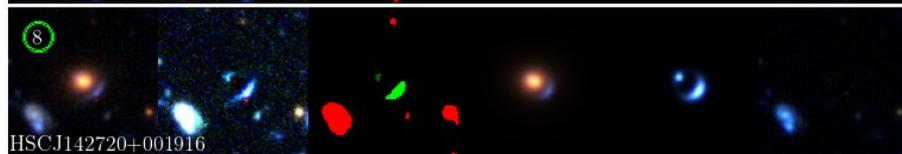Training data with real HSC features

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Simulated test sample
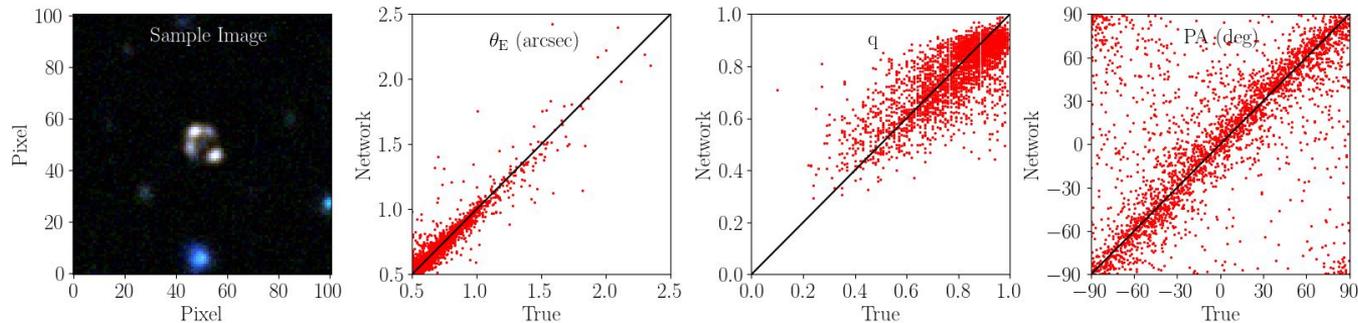
SuGOHI : grade A and B
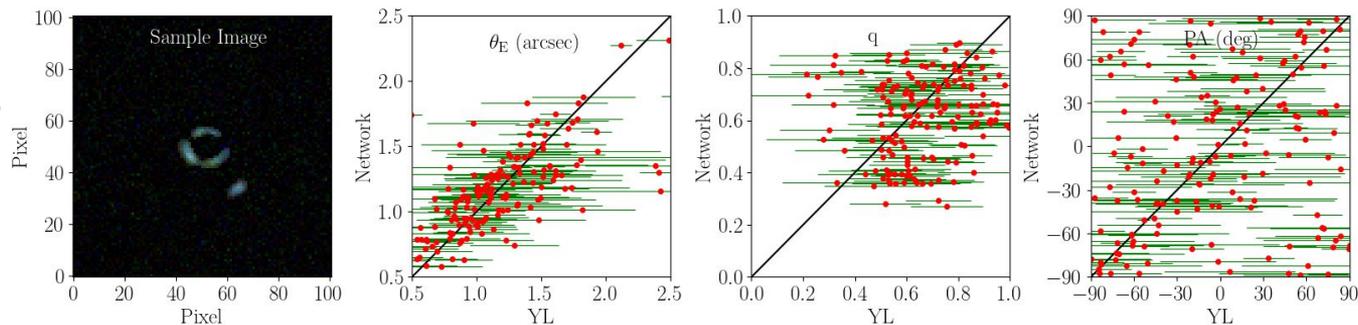
SuGOHI : grade A
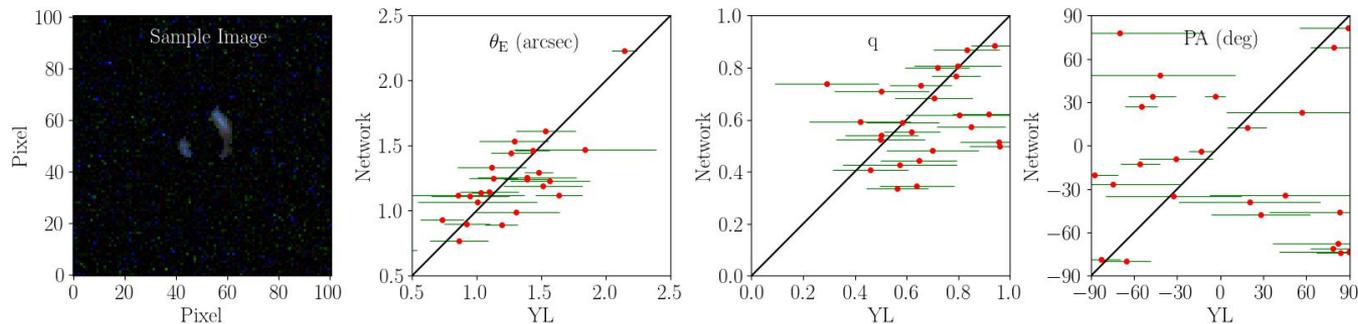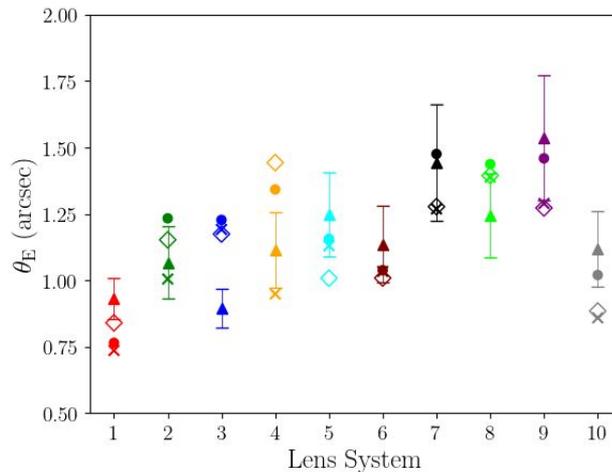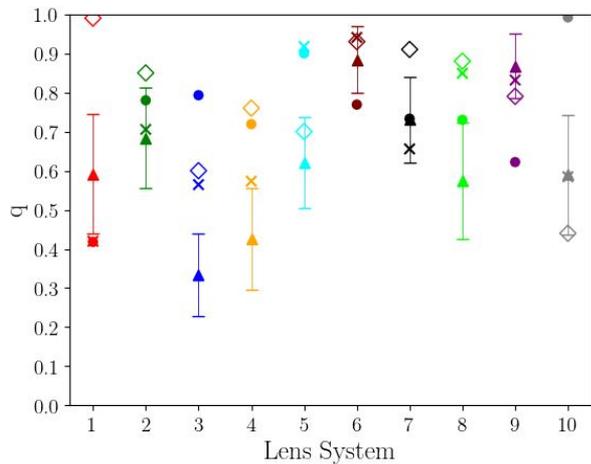
8

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YL modelling

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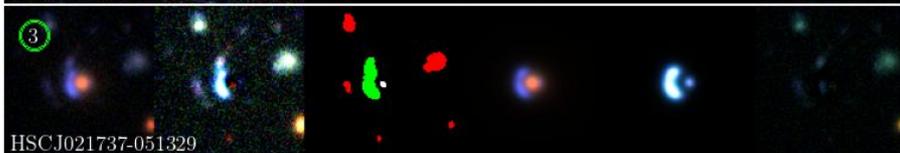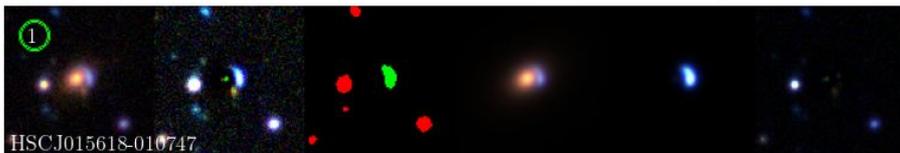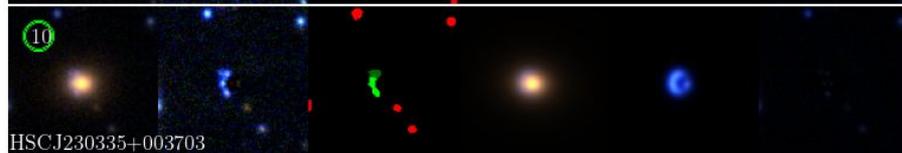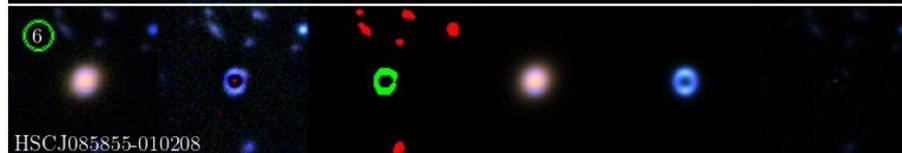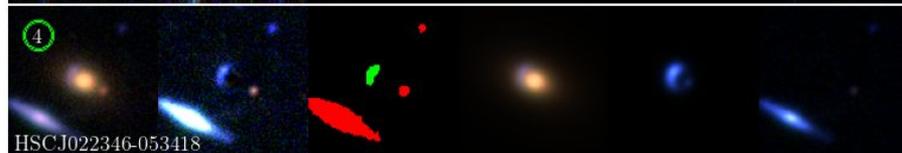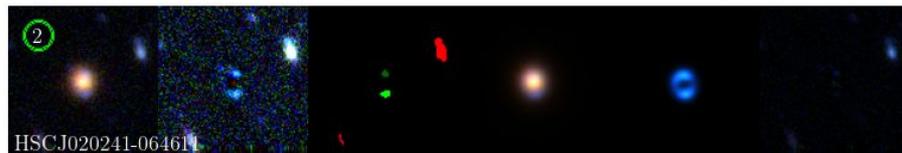
Comparing our results (CNN+YL) with Sonnenfeld et al. 2019 (S19), Schuldt et al. 2023 (S23)
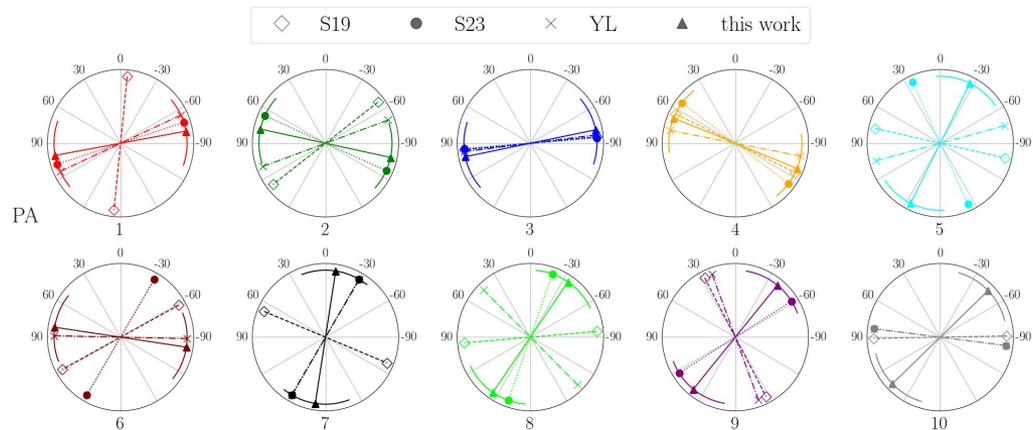
Position Angle

Axis ratio

Einstein Radius

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Summary and Future goals

- Summary:
  - Our network works well on the simulated lenses
  - For the 10 common lenses, none of the methods are consistently agreeing especially for q and PA
  - Differences in simulation techniques, models, limited data quality
  - Need reliable "true" parameters to compare our results with to draw any solid conclusion for the larger sample of SuGOHI lenses
- Future goals:
  - Develop a better lens light subtraction method using ML techniques
  - Include more lens and source parameters in the analysis
  - Include uncertainties
- For details and queries: Gawade et al. 2024 (arXiv:2404.18897), priyankag@iucaa.in
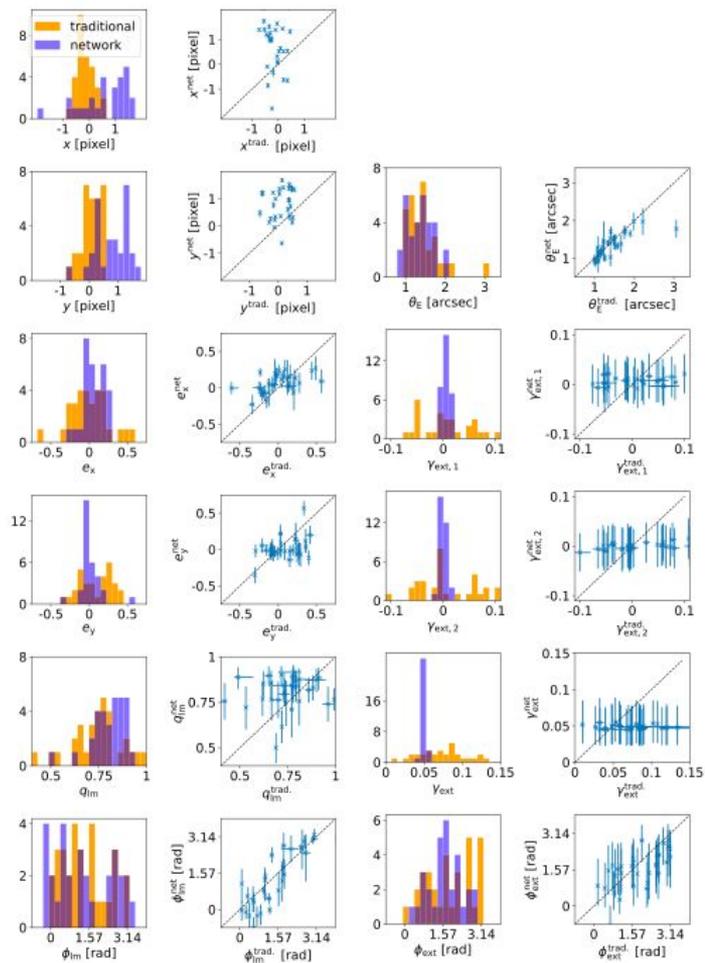
Thank You!

Backup slides

Schuldt et al. 2023

Comparison with Sonnenfeld
et al. 2019
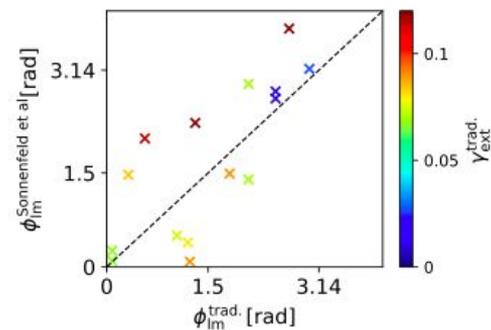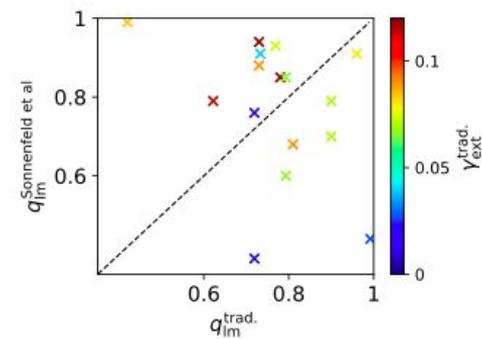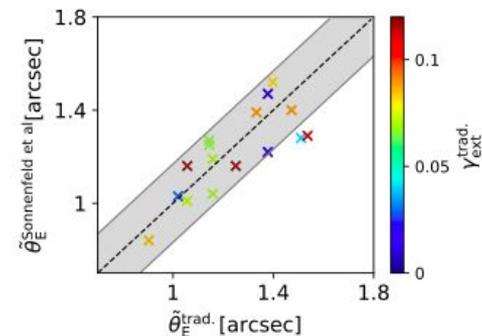
Schuldt et al. 2023

Network vs GLEE & GLAD

4. Comparison of the SIE+γ_{ext} values obtained with the traditional GLEE & GLAD method (orange histogram) and our ResNet (blue ...um). We further include a comparison where the GLEE & GLAD values are plotted against the ResNet values.