Politecnico di Torino

On the Sensitivity of Artificial Intelligence-based Observers to Input Signal Modification

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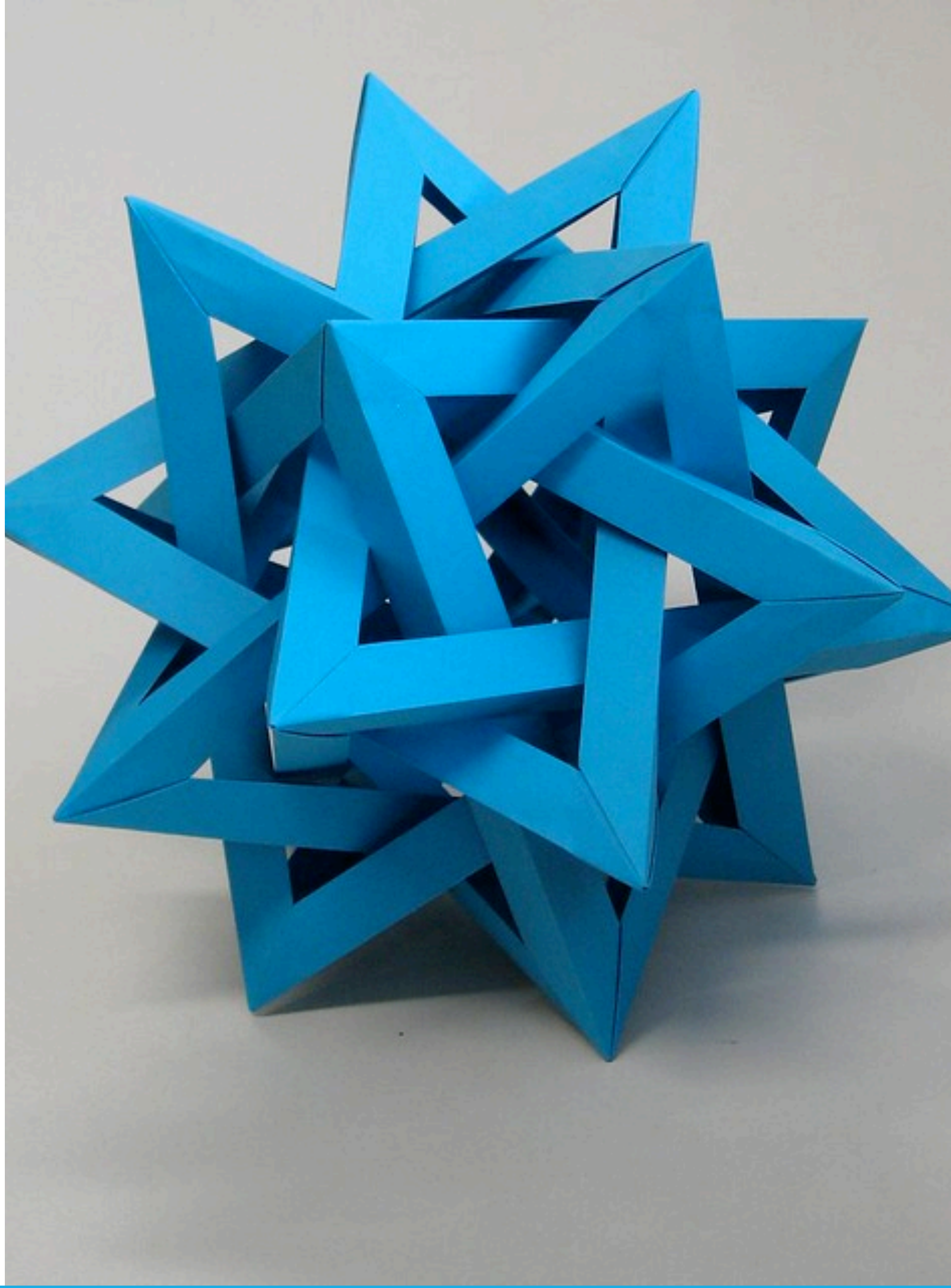
JEG-HYBRID

VQEG MEETING, MAY 2022



Artificial Intelligence-based Observer (AIOs)

- AIO: a NN trained to mimic an individual subject in terms of quality perception:
  - Predicting individual opinion scores rather than the MOS;
  - The AIO outputs a discrete probability distribution;
  - The realizations of such a distribution mimic the subjects’ inability to repeat previous assessment.

- Challenges:
  - Dealing with a learning task with very noisy labels;
  - The lack of training samples is further emphasized.

AIOs Training Approaches

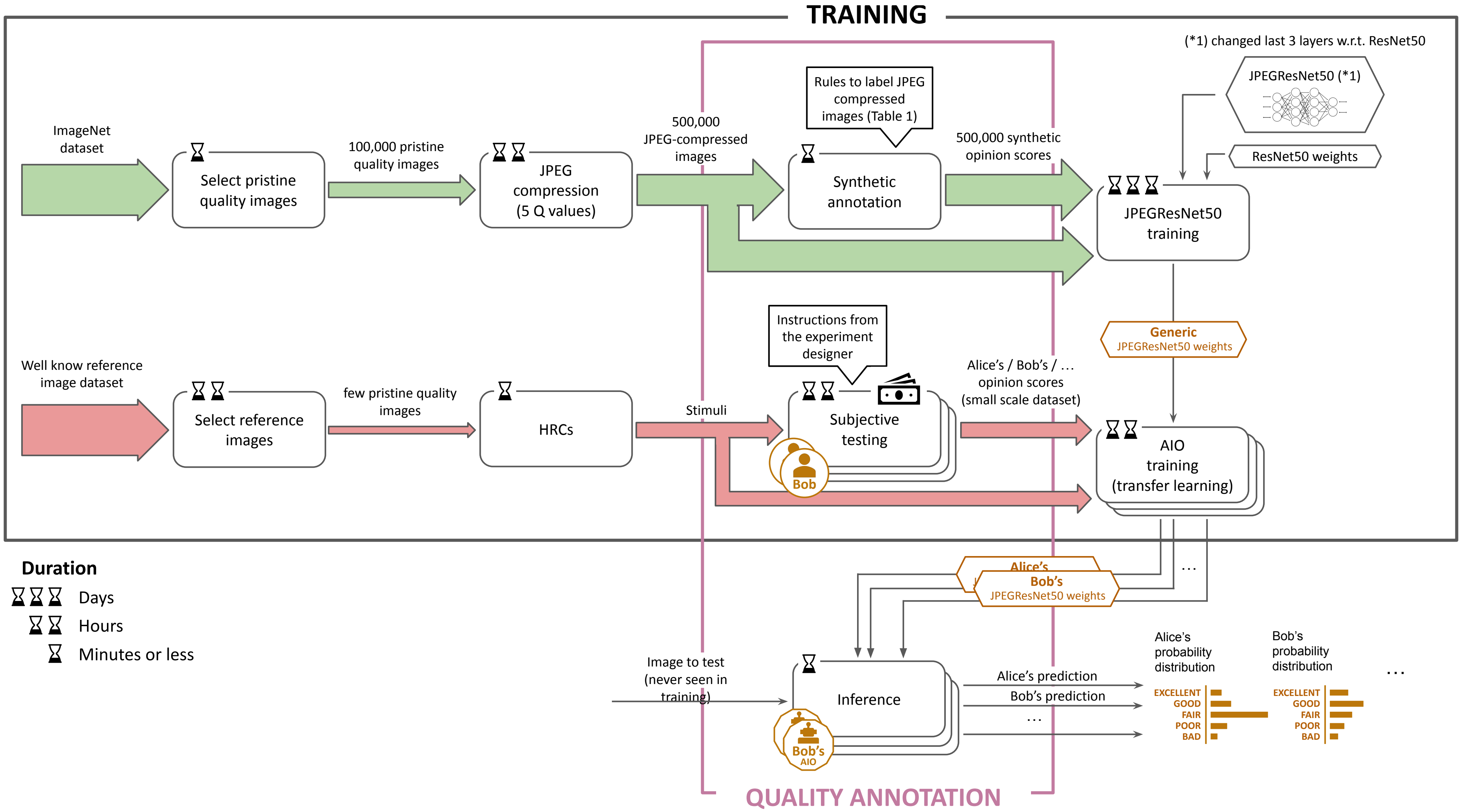
- Shallow NNs based AIOs: [1]
  - A common set of hand-crafted features;
  - Finding the best feature subset for each subject to be modelled;
  - Mapping selected features to subject ratings with a NN;
  - The NN architecture and the best feature subset change from one subject to the other.

- Deep CNNs based AIOs: [2]
  - Avoiding input signal approximation;
  - Avoiding hand-crafted features “over-generalization”;
  - Extracting “opinion-aware” individual features.

[1] L. Fotio Tiotsop, T. Mizdos, M. Barkowsky, P. Pocta, A. Servetti, E. Masala. ”Mimicking Individual Media Quality Perception with Neural Networks based Artificial Observers”. In: ACM Transactions on Multimedia   Computing, Communications and Applications

[2] L. Fotio Tiotsop, A. Servetti, T. Mizdos, M. Uhrina, P. Pocta, G.Van Wallendael, M. Barkowsky, E. Masala. ”Predicting Individual Quality Ratings of Compressed Images through Deep CNNs-based Artificial. Observers”. Submitted to Signal Processing: Image Communication.

Deep CNNs based AIOs: Training Approach



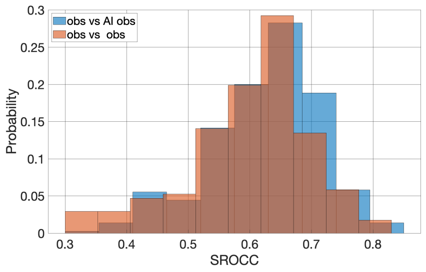
Results Discussed at Previous VQEG Meetings

- Shallow NNs based AIOs:
  - Show an accuracy that differs less than 12% from a benchmark value derived from a subjective test;
  - The AIOs' MOS correlates well with actual observers' MOS;
  - More accurate at the extreme of quality scale as humans;
  - The variance of the predicted probability distribution has the properties of a subject inconsistency measure.

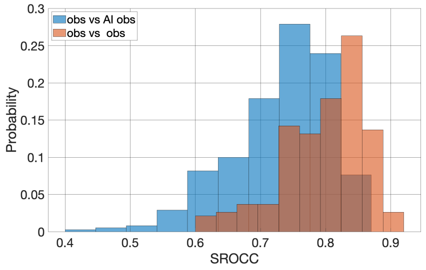
- Deep CNNs based AIOs:
  - Similar results as in the shallow NNs-based AIOs case;
  - Preliminary results on the comparison of AIOs to actual observers in terms of bias and inconsistency.

More Results on Deep CNN-based AIOs

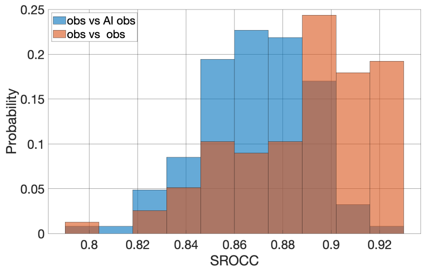
- Simulating the process of a subjective test:
  - Using the AIOs on the stimuli used in a subjective test;
  - Compute the values: corr(AIO, Observer) and corr(Observer, Observer);
  - Question of interest: can we trivially distinguish the AIOs from actual observers?



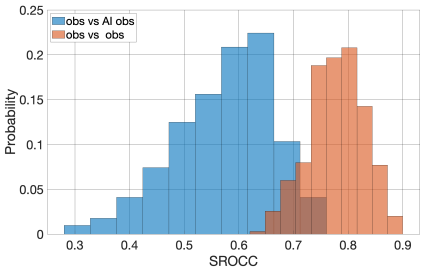
Training set



LIVE IQA PH1



LIVE IQA PH2



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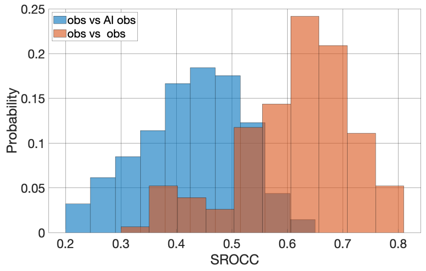
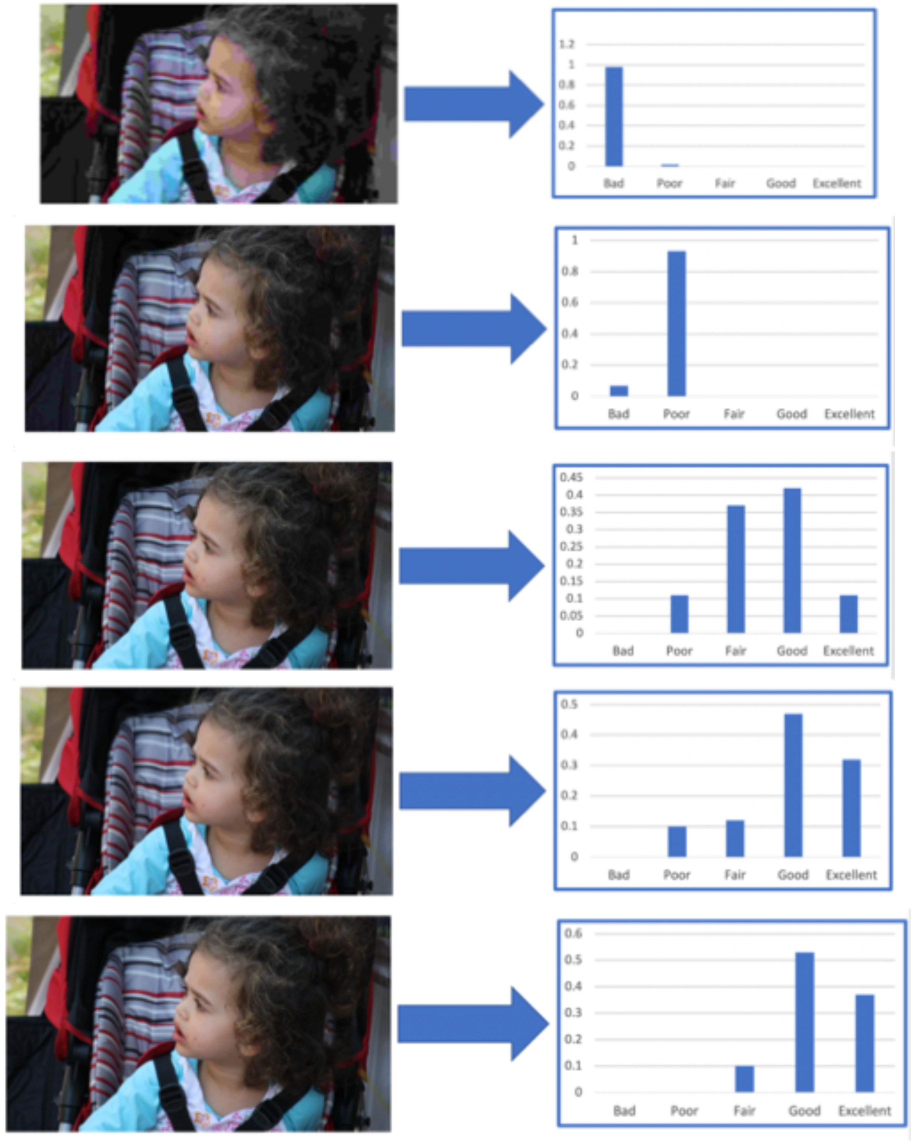


LIVE MD PH2

Some Results on Deep CNNs based AIOs



AIOs output as a function of the JPEG compression level

AIOs Robustness

- Shallow NNs based AIOs:
  - What if some noise is added to the input features?

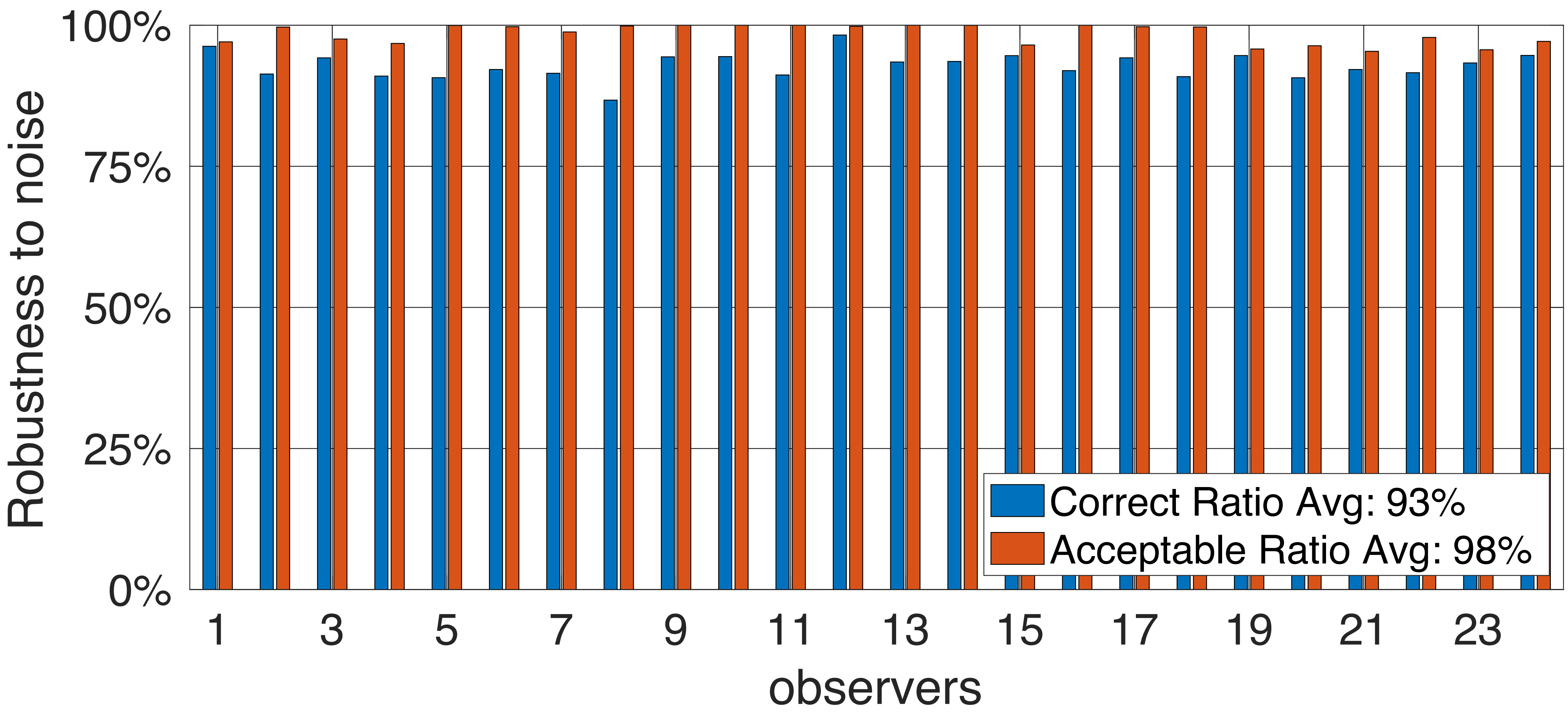
- Deep CNNs based AIOs:
  - What if the input image undergoes a transformation after which a human subject is “expected” not to change his opinion score?
  - To which extent the approach yielding the input image patch matters?

Shallow NNs based AIOs Robustness

- Adding a uniformly distributed noise to the input features:
  - noise range: between -1% and +1% of the feature “practical” variation range;
  - 10 000 noise realizations are considered for each AIO.

- Evaluation metrics:
  - **Correct ratio:** probability that the AIOs prediction will not change;
  - **Acceptable ratio:** probability that the AIOs prediction will move by at most one class on the ACR scale after adding the noise.

Shallow NNs based AIOs Robustness



Deep NNs based AIOs Robustness

- Input image modification:
  - From RGB to gray scale;
  - From RGB to RGB plus a not “perceptible” gaussian noise.

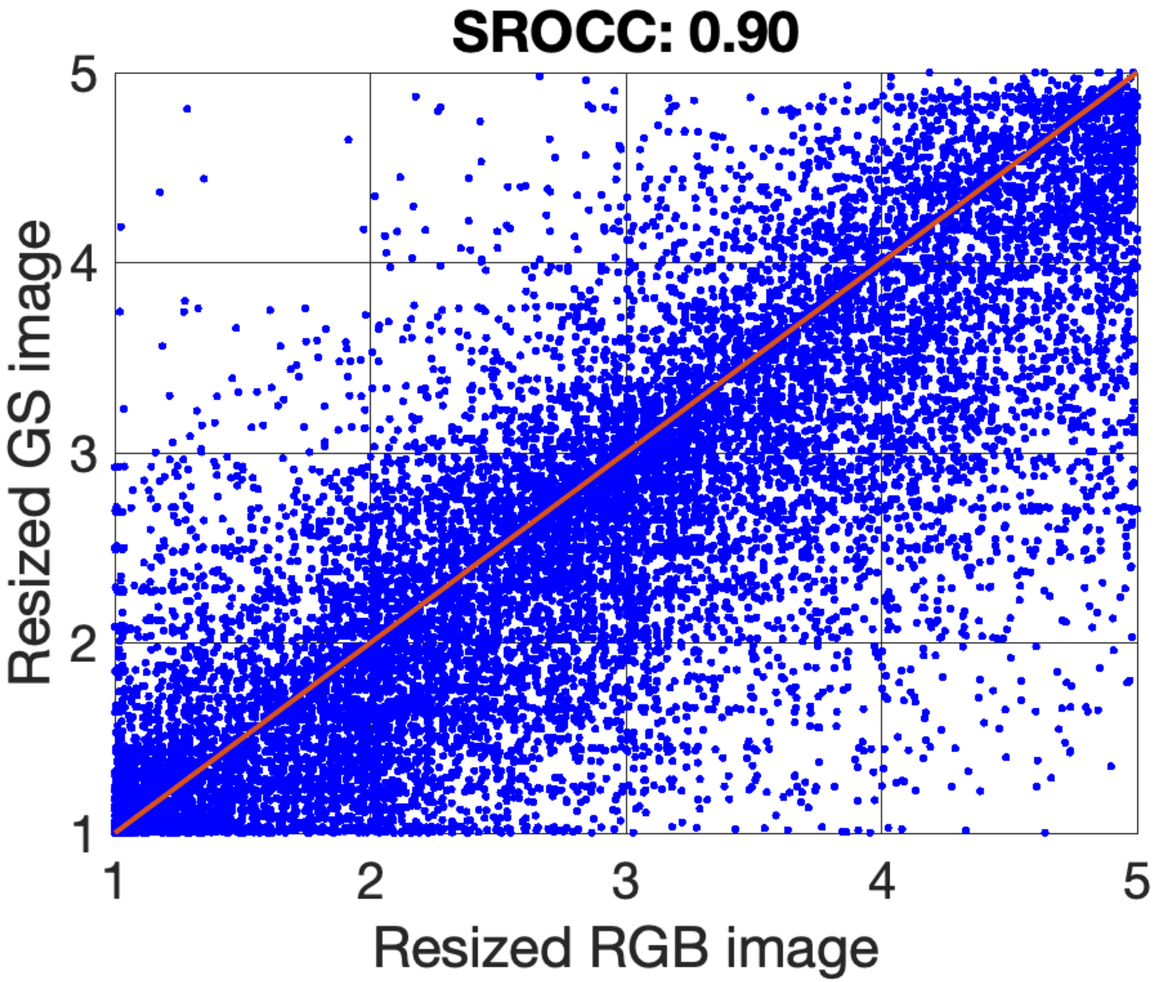
- Approach yielding the 224*224 input patch:
  - Resizing the input image (used during the training);
  - Center crop.
- Dataset:
  - 20 000 images: 4000 images*5 JPEG compression levels;
  - The 4000 original images were selected from the ImageNet competition dataset.

RGB vs Corresponding Gray Scale (GS) Resized Image

- Comparing the Mean Opinion Scores of the AIOs

RGB

GS

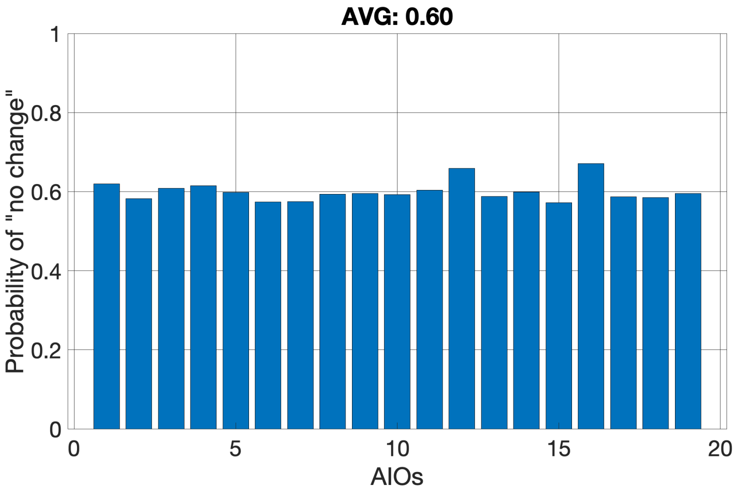


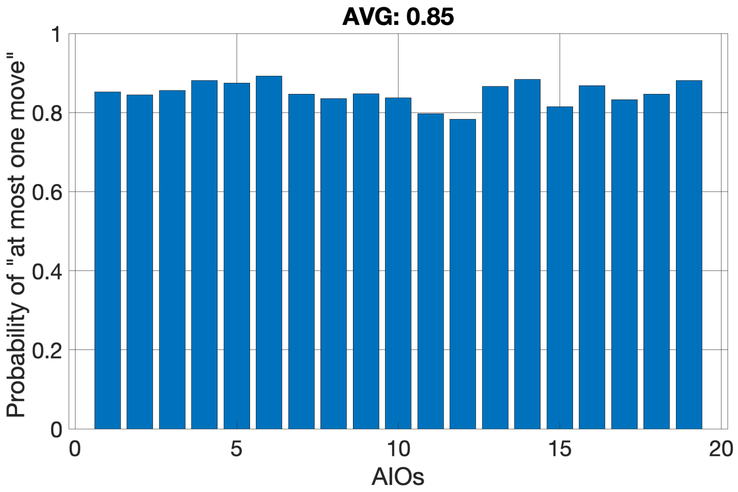
RGB vs Corresponding Gray Scale (GS) Resized Image

- What happens at the level of single subjects?

RGB

GS



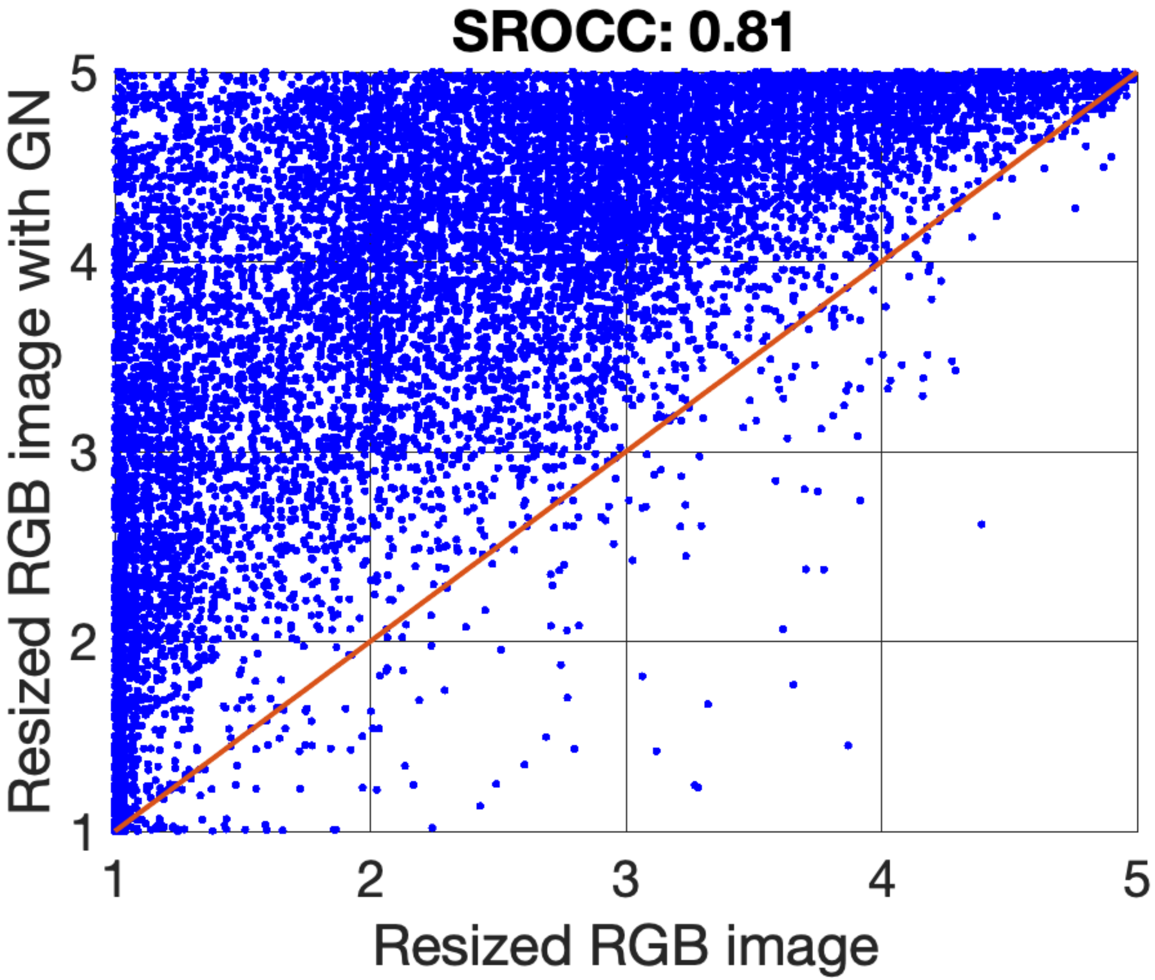


Adding a ”Not Perceptible” Gaussian Noise (GN)

- Comparing the Mean Opinion Scores of the AIOs

RGB

RGB+GN



Adding a “Not Perceptible” Gaussian Noise (GN)

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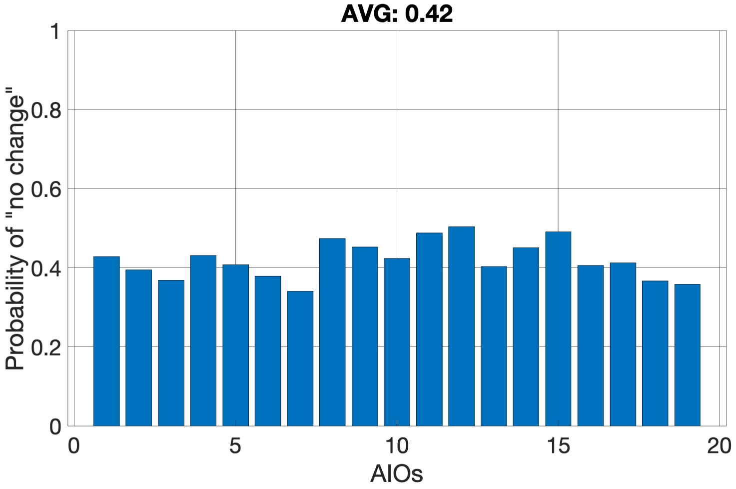
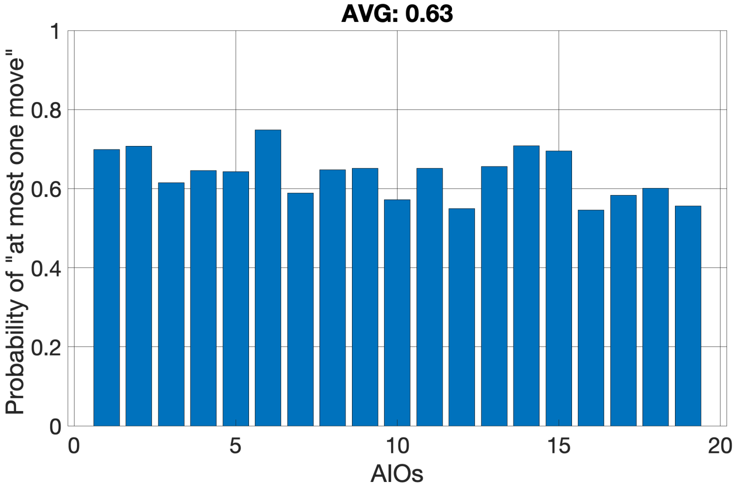


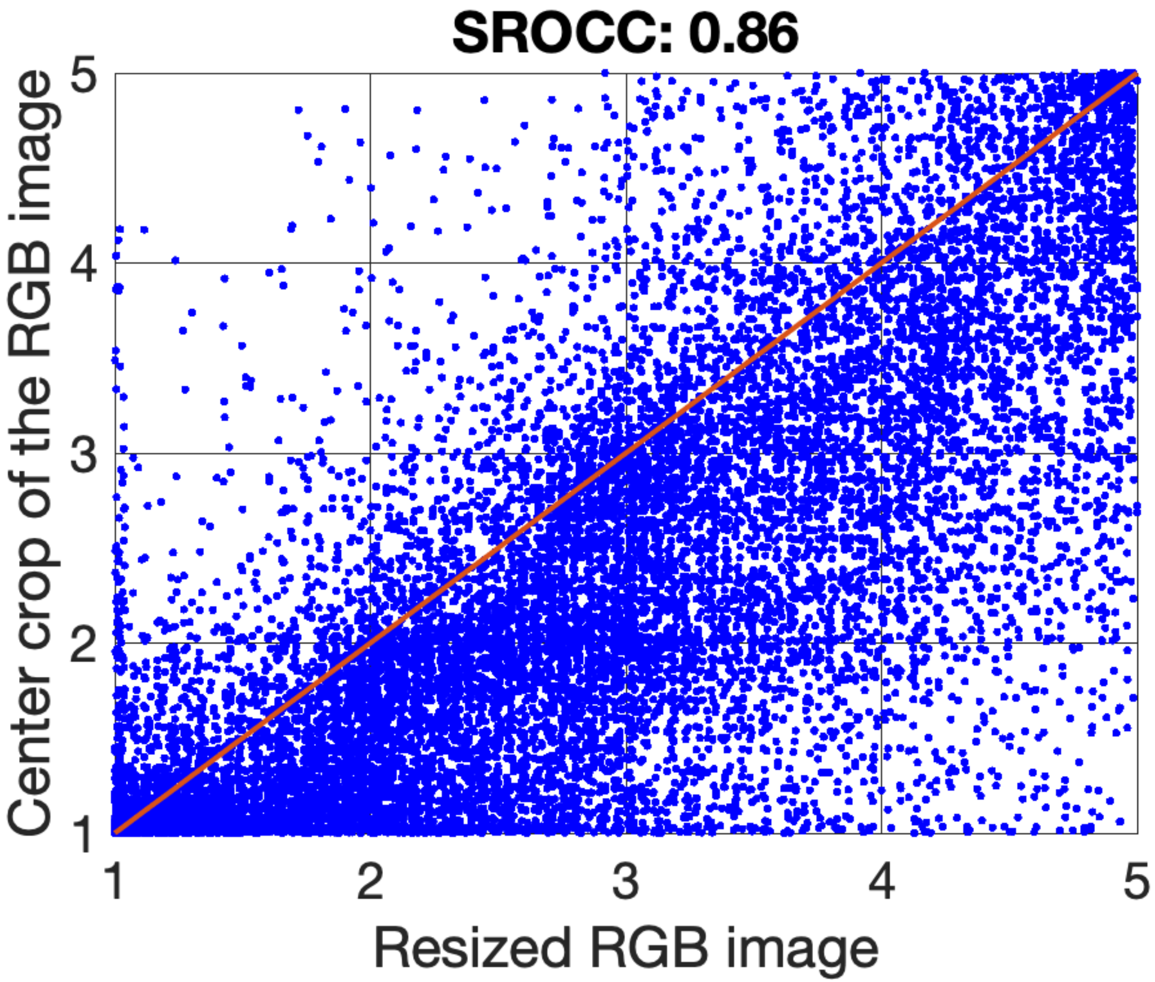


The Approach Yielding the Input Image Patch Matters

- Comparing the Mean Opinion Scores of the AIOs

Resized

Center Crop



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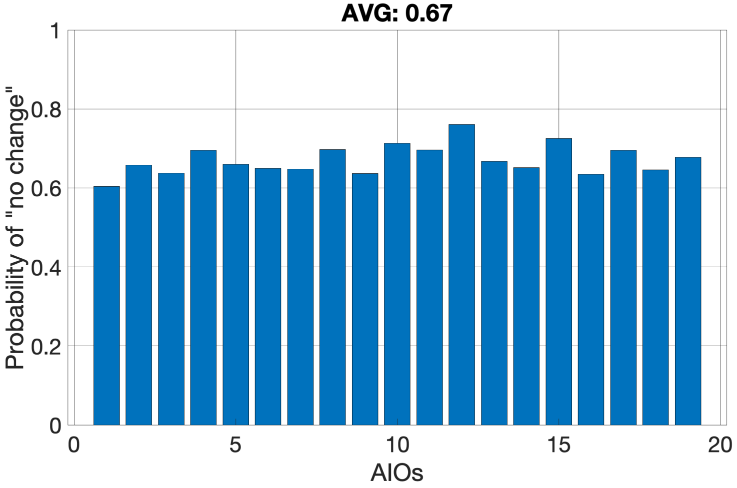

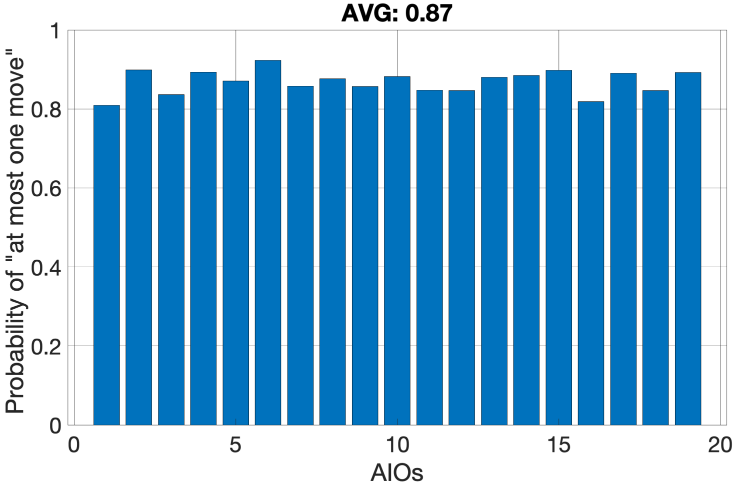

Next Steps

- Refining Deep CNNs-based AIOs:
  - Embedding data augmentation approaches to enhance the AIOs robustness
  - Should we crop rather than resizing?

- On the Robustness of Deep Learning-based Quality Measures:
  - Running the same experiments on other deep CNNs based metrics;
  - Is the issue task-related?