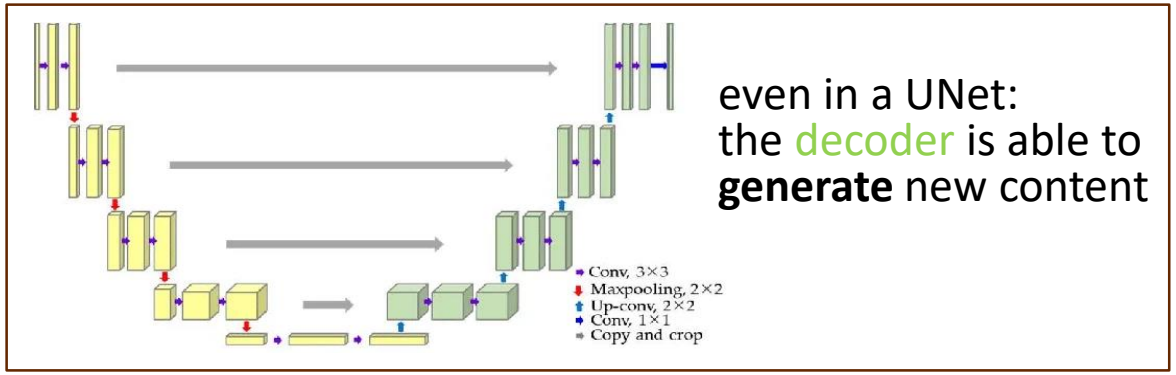
A few Remarks on Today‘s Astrophoto Processing

- Artificial Intelligence (AI) tools have also entered astrophotography
- In this context, AI typically means deep learning (DL) using deep convolutional neural networks, (D)CNNs
- Most of these algorithms are downplayed as mere „correction“ or „classification“, but in reality they are not; in fact, they exhibit characteristics of generative AI

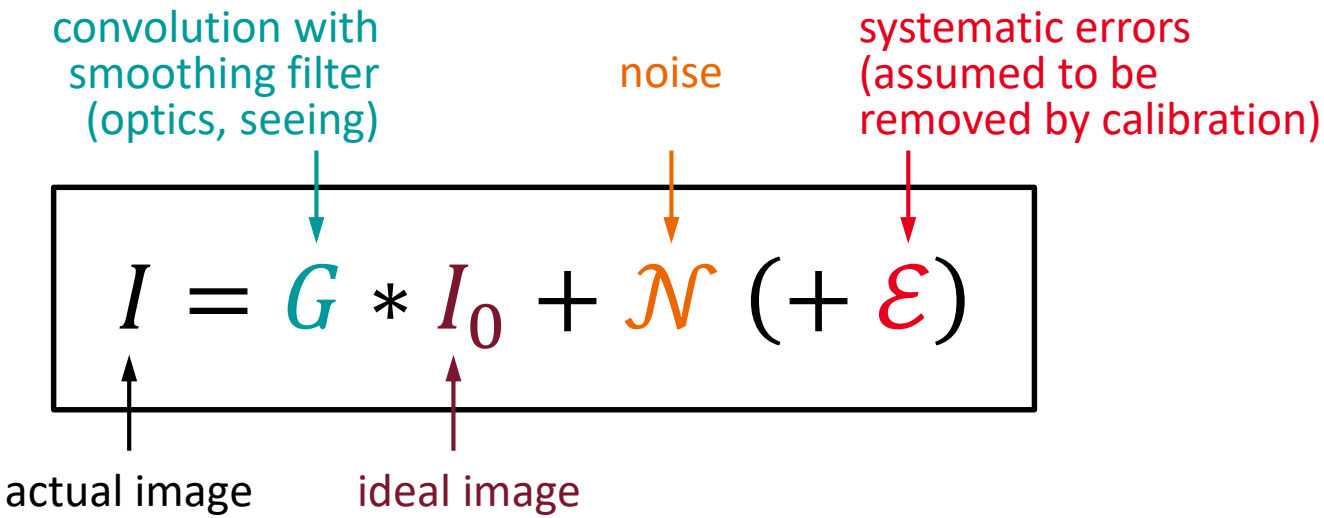


even in a UNet:
the decoder is able to **generate** new content

- CNNs tend to hallucinate, e.g., create stars/structures out of hot pixels or statistical fluctuations (noise)
- **In a scientific sense, most of these AI tools must be considered a form of data manipulation!**
- Unfortunately, it has become almost impossible to be awarded without using specific tools, particularly, for **denoising**, star reduction/„**star rendering improvement**“, and **star removal/separation**
- The results appear so plausible that arguing against them is difficult without comparison to a ground truth

The Inverse Problem

Forward processing:



Inverse situation:

- G can be motivated,
- but $\mathcal{N}$ is unknown!

Solution of the Inverse Problem:

"Calculate I_0 from I" → **generally impossible!**

if

- noise is present,
- or G has zeros in frequency domain

The Inverse Problem

$$I = G * I_0 + \mathcal{N}$$

- Calculation of I_0 from I is generally impossible.
- I_0 as a solution of the model is not unique, because there are infinitely many I_0s that satisfy the equation.

$\Rightarrow$

- **Exposure time cannot be virtually increased.**
- **Larger optics (aperture) or better seeing cannot be calculated.**

- The solution space is narrowed by prior knowledge, e.g.
  - Stars are sparsly distributed point sources
  - Signal-to-noise ratio thresholds
  - Smoothness constraints (regularization)

<u>Since the AI hype:</u>

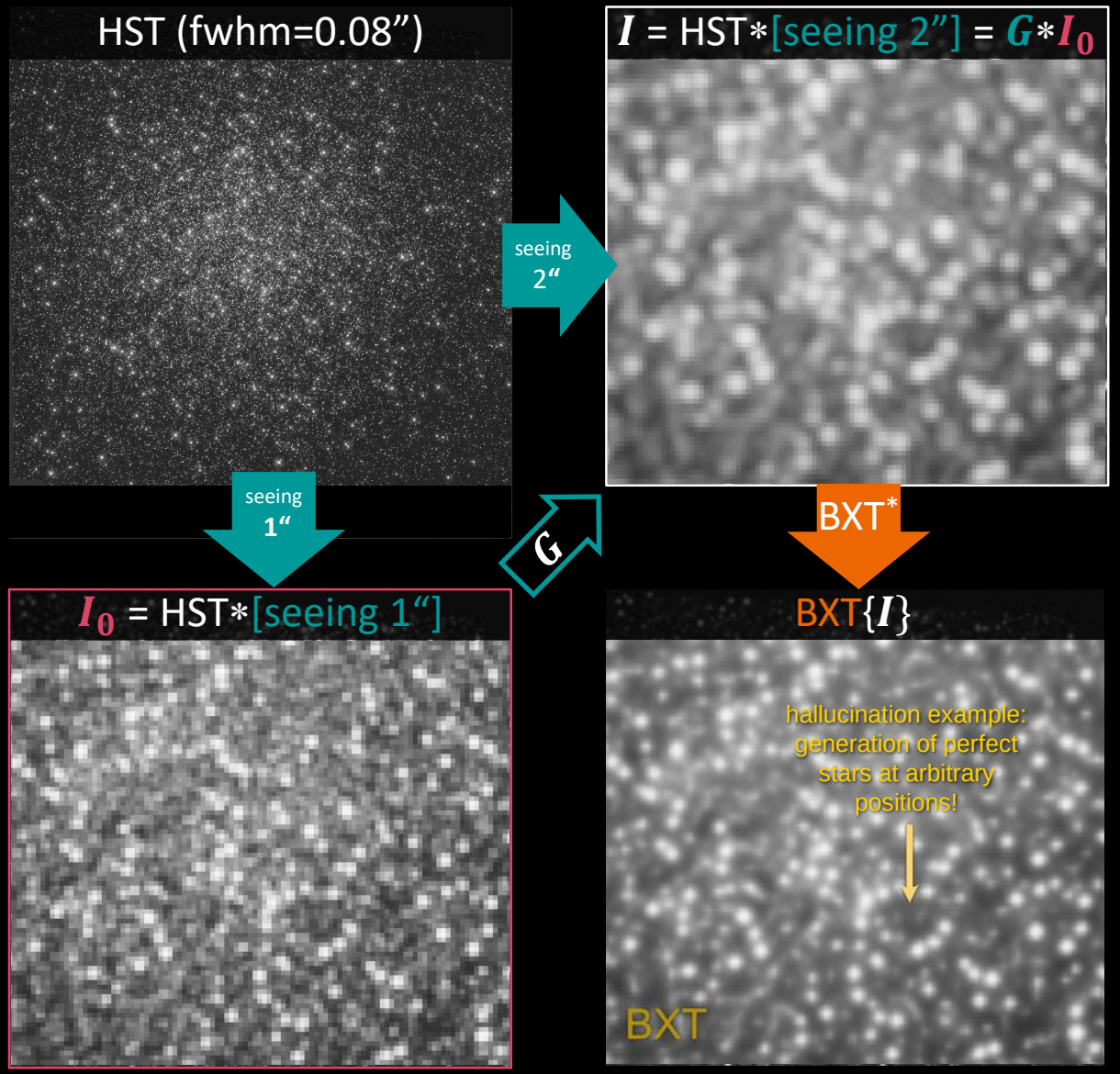
- Many people (developers/vendors) effectively claim, that "by training a CNN with pairs (I, I_0), the network can learn to solve the inverse problem."
- AI just introduces a highly complex level of assumptions (= trained prior knowledge)

NO!
Fundamental limitations are not overcome by any technique, also not AI.

Ground Truth Comparison

The RC Astro BlurXTerminator, a claimed deconvolution

- HST image of the GC Messier 13
- Central region with high star density
- Generation of test images by convolution



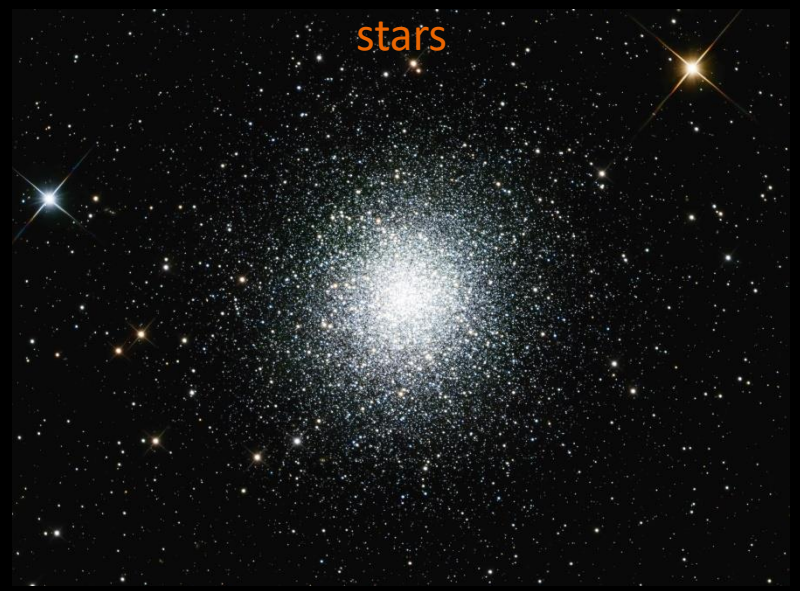
- The BXT synthesizes perfect stars if they are sufficiently isolated
- Blurry content in between
- Reason: No approach is able to distinguish between noise and overlapping stars beyond the resolution limit
- A conventional deconv. would also have to make compromises at low signal-to-noise ratio, but not act generatively

* Software: RC Astro BlurXTerminator, parameters selected to match PSF (FWHM) of I_0

Star Removal/Separation

The RC Astro StarXTerminator

SXT*



- Obvious misclassification!
- Reason: star density is higher than resolution limit of the signal chain
- Useful for removing artifacts (e.g. satellite tracks) from background
- Unfortunately, many astrophotographers use this workflow with completely separated stretching and processing of both components
  - leads to propagation of hallucinations
  - unscientific data manipulation

* Software: RC Astro StarXTerminator, applied to linear data prior to stretching