In recent years, there has been a growing interest in machine learning (ML) in virtually all fields of science. Also in astronomy, artificial intelligence methods begin to play a significant role in various measurement and identification processes. The main tasks faced by these methods are detection, classification and clustering of objects, simulation and prediction of phenomena.

The objective of the proposed **ML-astro** project is to use deep neural networks (DNNs) constructed as autoencoders to improve the quality (both in terms of signal-to-noise ratio and effective resolution) of astronomical images acquired from ground-based small telescopes (i.e. <1 m main mirror diameter). For this purpose, during the project, we will use the data from the range of astronomical instruments available at our observatories, including a remote one in Otivar (Spain). The data acquired include all the real aspects of astronomical imaging that are extremely difficult or even impossible to simulate. These include: changing atmospheric conditions, the use of different photometric filters, setting different exposure times, inaccuracies in the process of guiding the telescope, image distortions resulting from changing thermal conditions inside the instrument and its housing, observing objects at different heights above the horizon accompanied by different atmospheric turbulence and refraction conditions, and many others that have not yet been comprehensively taken into account in known research works.

The dataset obtained this way will serve as a training set for various state-of-the-art models of autoencoders to perform the function of reconstructing the image to the form it takes in a much larger, reference telescope. Our main task is to answer the question: ARE THE MACHINE LEARNING METHODS ABLE, AFTER AN APPROPRIATE TRAINING PROCESS, TO SUPPORT NIGHT OBSERVATIONS WITH SMALL TELESCOPES SO THAT THEIR IMAGES ARE AS CLOSE AS POSSIBLE TO THOSE OBTAINED WITH AN INSTRUMENT OF A MUCH LARGER COLLECTING APERTURE AND BETTER OPTICAL QUALITY? Thanks to the application of ML we hope to increase the quality of objects' photometry (brightness measurements), astrometry (position measurements), and imaging resolution, which are the factors most important for astronomers.

We would also like to find an answer to another question: IS IT POSSIBLE, WITH ADDITIONAL MINIMAL TUNING, TO USE A PRE-TRAINED AUTOENCODER TO IMPROVE IMAGES FROM ANOTHER SMALL TELESCOPE WITH VERY DIFFERENT IMAGING PROPERTIES (DIFFERENT CONSTRUCTION, FOCAL LENGTH, PIXEL SIZE? Through such transfer learning, we wish to test the feasibility of using pre-trained autoencoder models to improve images from a wide range of astronomical optical instruments, making the methods applicable in small observatories.

After deep literature research, we identified 19 publications starting from the pioneering work 2017 (see https://arxiv.org/abs/1702.00403) in the field of enhancement of astronomical images with ML. We found several fundamental limitations and problems of these methods: (1) poor or even no practical application in real-world observatories, (2) lack of solutions for small telescopes which are in fact the majority of instruments operated from the ground, (3) experiments and training only on synthetic datasets, (3) lack of robust reliability analysis (identification of artifacts, errors in photometric or astrometric measurements, etc.), and (4) applications mostly in solar observations (nighttime observations is what we are mostly interested in).

To overcome all the problems formulated above, our main aim is the practical application of DNNs in the form of autoencoders to improve astronomical images. Our targets are therefore small telescopes; the training database contains real, not synthetic, image sets acquired from ground-based instruments; the verification of the efficiency of the algorithms will be based on indicators relevant to astronomers, i.e. (1) the object detection efficiency, (2) the photometric quality, (3) the astrometric precision, as well as (3) the improvement in resolution.

In this project our main task is to answer the questions: (1) are the machine learning methods able, after an appropriate training process, to support night observations with small telescopes so that their images are as close as possible to those obtained with an instrument of a much larger collecting aperture and better optical quality? (2) is it possible, with additional minimal tuning, to use a pre-trained autoencoder to improve images from another small telescope with very different imaging properties (different construction, focal length, pixel size?