Single lens imaging system

Objective
To study imaging properties of a lens system; concepts include image formation using the basic lens formula, magnification, and resolution of the imaging system.

In the lab you will find optical elements to setup imaging system, including HeNe laser, adjustable iris, collimating lens of focal length $f=380\,\text{mm}$, lens of unknown focal length $F$, and microscope objective. The object is an AF Resolution Target which has sets of horizontal and vertical bars of varying size and spacing. The resolution data for this target are posted in the lab.

Collimating with a mirror and an iris:

When placing a lens into an optical system:
- keep laser beam propagating in the same direction after the lens;
- lens should be placed perpendicular to the laser beam.

- Place microscope objective (compound lens with very short focal length) into the laser beam.
- Place collimating lens approximately one focal length away from the microscope objective to get an almost collimated beam.
- Insert iris right at the output of the lens, center it on the beam, and adjust its size to allow about 80% of the light through.
- Place mirror at the far end of the optical bench. Adjust it until the reflected beam is centered on the iris.
- Adjust the position of the collimating lens until the reflected beam size is the same as the forward beam through the iris.

Experiments

A. Magnification of the Imaging System
- Place lens of unknown focal length into collimated laser beam. Place observation screen after the lens and move it until you get the smallest laser spot. Measure the distance between lens and screen, it will be $F$.
- Place resolution target at two focal lengths (2F) before the lens and observation screen at two focal lengths (2F) after the lens. Describe the image with respect to the object.
- Using the lens formula: \(1/d_0 \pm 1/d_i = l/F\), $(d_0$ is the object distance and $d_i$ is the image distance), find the magnification of the system $M = d_i/d_0$. Measure the size of the image. (It should be about 13mm by13mm for the biggest square 0-1.)
- Using the lens formula find $d_i$ and $d_0$ to get $M = 2$. Place object, lens, and screen at calculated distances. Measure the image size to verify that $M = 2$.

B. Image quality / Resolution of the Imaging System
- Substitute CCD camera for the observation screen (you may need adjust camera position for the sharpest image). Observe the resolution target features on the monitor and find the best resolution achievable.
- Invert the object and image distances, and estimate the magnification. (Slightly adjust lens position for the sharpest image.) What is the resolution now?
- Go back to $M = 2$ imaging system. Position an iris between the lens and object as close to the lens as possible. Make sure that the iris is centered on the lens and fully opened. Observe the highest resolution of the image. Reduce the iris aperture to about 5mm and comment on the effect of image quality and brightness. Is the image quality better or worth? Record the resolution corresponding to both iris apertures.