Project 7 (CCD ballistics):

Every day we are exposed to visual imagery. While in the past the confidence in the integrity of images was high, today's digital technologies have eroded this trust. Doctored photographs or images of questionable fidelity appear in increasingly greater frequency and sophistication. In the realm of forensics, DNA analysis and groove ballistics have been used for forensic identification. In the digital domain, the emphasis lies on the pixel. In this project the student has to study and analyze different pixel-level correlations to reveal images that are hampered.

1) In ballistics the markings of the grooves on the bullet are studied in order to uniquely identify a weapon. Before moving and image from the CCD to the memory a number of steps are performed like quantization, white balancing, color/gamma correction filtering and potentially JPEG compression. This processing imprints a unique signature on the image, which is stochastic spread-spectrum watermark, which survives processing. This signature is "fingerprint" of a CCD. The student has to study different noise models that describe this process. Using approximately 50 images or fewer low-pass images (i.e. the sky) the student has to derive the sensor noise for different cameras and try to identify them. Can we verify if an image was taken from camera A or B? It should be noted that camera response is point-wise non-linearity that is used to enhance the image. Differences in the response function of a CCD can be used to detect tampering.
2) CCDs capture color information using a color filter array (CFA). The CCD employs three color filters (red, green, blue) placed atop sensor elements with periodic repetition. Then the color information is recovered using interpolation from the neighboring pixel elements, each of which having a different single color filter atop. Chromatic aberration can be modeled as displacement between the red and green channels. In reality it is a spatial shift in locations where light of different wavelengths reaches the sensor. Bu maximizing the global and/or local alignment of color channels one can detect color aberration. Can you devise and algorithm to detect color aberration in images. Do the local and global estimates of aberration match?
3) (Optional) Galactic disks can be seen from different angles with respect to the CCD sensor. The two extreme cases are face-on and edge-on. Could you rectify an image of galaxy, so that it appears as it is viewed edge on? Under which conditions can this be done?

References:

1. H. Gou, A. Swaminathan, and M. Wu, "Robust scanner identification based on noise features," in *Proc. SPIE, Electronic Imaging, Security, Steganography, and Watermarking of Multimedia Contents IX*, San Jose, CA, Jan. 29–Feb. 1, 2007, vol. 6505, pp. 0S–0T

2. B. Sankur, O. Celiktutan, and I. Avcibas, "Blind identification of cell phone cameras," in *Proc. SPIE, Electronic Imaging, Security, Steganography, and Watermarking of Multimedia Contents IX*, San Jose, CA, Jan. 29–Feb. 1, 2007,vol. 6505, pp. 1H–1I.

3. T. Gloe, E. Franz, and A. Winkler, “Forensics for flatbed scanners,” in *Proc. SPIE, Electronic Imaging, Security, Steganography, and Watermarking of Multimedia Contents IX*, San Jose, CA, Jan. 29–Feb. 1, 2007, vol. 6505, pp. 1I–1J.

Further information and assistance for this project can be obtained from Dr. Panos Lambropoulos (panos@astro.rug.nl or panos@astron.nl)#