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Cherenkov Telescope Array: Mirror Alignment Project Software Solutions to Increase Positional Resolution

Once it is built, the Cherenkov Telescope Array (CTA) will be an array of ground-based telescopes that intends to observe gamma rays lower than 100 GeV and up to 100TeV. This will enable to us see previously undetectable sources, as present day Cherenkov telescopes observe in the 100 GeV to the 10 TeV range. Once is it built, the CTA will also be considerably larger than any current telescope arrays, with more than 50 telescopes total. In order to ease the cost of production, transport, and assembly, a new telescope design has been developed. Whereas telescopes now have one primary mirror, a portion of the telescopes in the CTA will have a series of smaller mirrors arranged into the shape of larger mirror. There will be one large primary mirror in the center, surrounded by two concentric rings of smaller mirrors.To preserve the mirror's shape, a system is being developed which controls each of the individual mirrors. The essence of the mirror alignment project is set of webcams and orthogonal lasers placed behind each mirror. The webcams are able to capture the position of neighboring lasers. From the location of the lasers spot on the webcam's images, it is possible to determine the relative positions of each mirror by calculating the centroids of the images. Once the relative positions are determined, a system of actuators is responsible for moving each mirror. Many issues arise in trying to calculate the image centroid. The primary issue is noise, which is diffused throughout the image. Each pixel of the image has a value from 0 to 255 depending on its brightness, with 255 being the brightest. Average noise level of the image can be anywhere from 10 to 20. Using several methods, attempts have been made to reduce the effect of this noise on the centroid calculation. The first method used, the Limited Range Method, was to reduce the region of the image which was analyzed. First, an analysis of the full image is conducted in which the centroid is calculated, as well as the Root Mean Square, RMS, values of the light distributions along the X and Y axis. Using the RMS value and centroid, we can pick out the region of the image which is made up primarily of the laser spot. Once this region is calculated, another analysis is run on this region alone which calculates the centroid. Using this method, we found that we were able to reduce the error in centroid calculation by an approximate physical distance of 5 microns to 1 micron. If the noise level is too high initially, the centroid calculations for the full size of the image is thrown off and it is not possible to reduce to the image to the region of interest. Currently, a new method is being developed to help determine the noise level of each image and ignore this noise level. For this, the average value of each pixel outside of the RMS region is determined. Then, in the centroid calculation, any pixel under a certain multiple of the noise level is ignored. The methods mention above are still imperfect and are being tested to determine their limitations. Depending on the results of further testing, these methods will be adjusted or new methods will be developed to determine the centroid of these images.