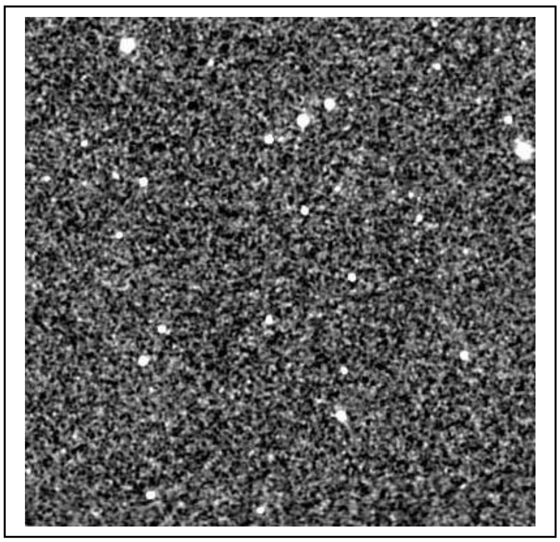
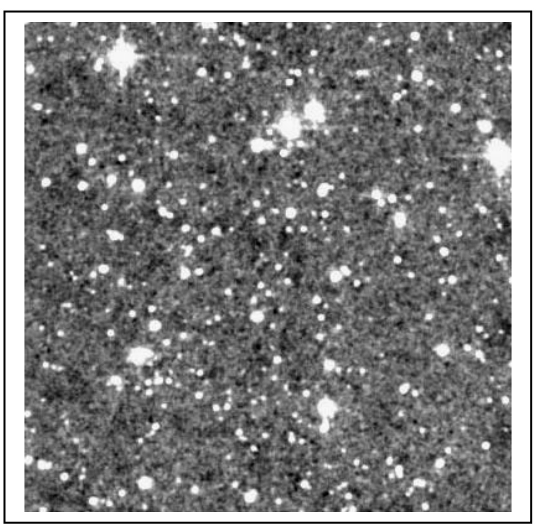
You are, by now, probably familiar with the mathematical procedure of averaging numbers together. When we combine images together, we can use data averaging to make faint things stand out more clearly. To see why this happens, let's imagine a picture that consists of a string of just 5 pixels (out of the 3 million pixels that might exist in a typical digital camera image!). Let's take a snapshot of exactly the same scene 9 times without moving the camera, and note the values of the intensity numbers in each pixel. Here's what you might get:

Pixel	1	2	3	4	5	6	7	8	9	Average
1	120	122	120	123	110	114	112	110	110	**116**
2	125	115	110	130	115	110	113	110	109	
3	130	133	131	128	130	130	131	129	130	
4	122	125	123	120	110	105	115	120	110	
5	122	125	123	109	110	114	120	105	115	





Problem 1 - Calculate the average value of the 9 images for each pixel by completing the table. The first Pixel has been done already.

Problem 2 - Scientists discriminate between background 'noise' and 'source' whenever they look at an image. Background noise has the property that it averages to a relatively constant intensity that is nearly the same everywhere in the picture. A Source, however, tends to stand out in only a few pixels, and with an intensity brighter than the background. From the five pixel image, which pixels do you think have mostly Noise, and which have mostly Source?

Problem 3 - How easy would it have been if you only had Pictures 1 and 4 to work with in trying to study the faint source in the field?

Problem 4 - If you are trying to detect a faint source against a bright background, what is a good Rule of Thumb to use?

Problem 5 - The two images are from the 2MASS infrared sky survey. The bottom image is an average of over 5000 images like the one at the top. Can you find 5 stars that are present in the 'coadded' image below but not seen in the single image?

Answer Key

Problem 1 - Answer:

Pixel	1	2	3	4	5	6	7	8	9	Average
1	120	122	120	123	110	114	112	110	110	116
2	125	115	110	130	115	110	113	110	109	**115**
3	130	133	131	128	130	130	131	129	130	**130**
4	122	125	123	120	110	105	115	120	110	**117**
5	122	125	123	109	110	114	120	105	115	**116**

Problem 2 - Answer: From your averages in Column 11, you can see that Pixels 1, 2, 4 and 5 have very similar averages, while Pixel 3 has a very different average value. This means that Pixels 1,2, 4 and 5 behave like Noise in a roughly constant intensity background, while Pixel 3 looks a lot like a Source.

Problem 3 - Answer: It would have been very difficult because the Background Noise level that was detected in Pixel 2 in Picture 1 and Picture 4 sometimes got as intense as the faint source itself in Pixel 3.

Problem 4 - Answer: A good Rule of Thumb would be to take as many pictures of it as you can, and then average the pictures together to make the faint source stand out more clearly.

Problem 5 - Answer: Students will have an easy time of finding many such candidates. The top image was taken by a 1.5-meter telescope that can detect light at an infrared wavelength of 2.2 microns. (Sunlight has a wavelength of 0.6 microns). The exposure was only 7.8 seconds. The bottom image represents an exposure of 7.8 x 5000 = 39,000 seconds and is able to see stars nearly 10,000 times fainter than the shorter exposure image.