Subject: Rabbit and Owl count megapixels

"... which clearly shows," said Rabbit, "exactly how many angels can dance on the head of a pin, AND how many of them will be in focus."

"Oh, well done, Rabbit," said Kanga, perhaps a little wearily.

It was a languid early evening, and the animals (even Owl, who had only just woken up) had gathered at the sunny end of a clearing in the Hundred Acre Wood. Each was engaged in a favourite pastime. Rabbit was talking, Pooh was humming, Piglet was lying back with his eyes closed -- so that nothing would distract his listening to Rabbit -- and Tigger was bouncing around in the hope that nobody would realize that it was bedtime for him and for Roo.

Eeyore, who had been having a wonderful time feeling gloomy, added, "Well done, indeed, Rabbit. Nobody could have gone into more detail on the subject. Even if they had wanted to. Which I doubt. But I thought that Owl and you were supposed to have been counting megapixels."

"Oh, we did that too," said Rabbit. "Ever since the Great Alexander posted the estimate that a digital camera would need 54 megapixels to match a medium speed 35mm film; and the Remarkable Rob quoted a source as saying that 1200 pixels per inch -- 1.9 megapixels in all -- would be enough."

Piglet sat up suddenly and said, "But surely that shows how irrelevant these numbers are! If two reputable sources can come to such different answers what's the use in counting megapixels?" He felt very daring, disagreeing with Rabbit like this.

"Well, yes, we knew that there are many who share your opinion, Piglet," responded Rabbit, "which was why I gave you all the pinhead results first. But we do believe we have some useful megapixel results too."

"Oh, that's all right then," said Piglet. "I'll just lie back and close my eyes again, so that I can concentrate better on what you are saying."

"But I thought you'd reached a rather simple conclusion," said Kanga. "Didn't you, Owl?"

"A quarter past six," said Owl. "Coffee."

So Kanga decided she'd summarize the results quickly, before Owl had a chance to wake up fully:

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*
* THE SHORT ANSWER ...
*
* ... is that ordinary careful amateur photography can record about
* 6 megapixels on a frame of 35mm film.  Once 6 megapixel SLRs are
* available with a reasonable speed -- oh, say ISO 400 -- and at a price
* that's hundreds of pounds rather than tens of thousands of pounds, we
* can reasonably expect amateur photographers to go digital in droves.
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Piglet sat up again. He felt Very Strongly Indeed about this. "Not droves," he said. "You have cattle drives, so it's reasonable for cattle to do things in droves. But who ever heard of a pig drive, or a drove of owls? You have a parliament of owls, not a drove."

"Mum," said Roo. "Why do we call a groups of owls a parliament?"

"Well," said Kanga. "A parliament is where politicians get together to talk about laws and government policies."

"Yes," replied Roo.

"Do you know anybody who does more talking than Owl?"

Pooh stopped humming and thought for a bit. Six million pixels was an awful lot. How could anybody count six million of ANYthing without making a mistake? He wondered whether he should ask for a hand recount, but then decided that That Would Not Help. Some of the American gray squirrels in the Hundred Acre Wood were very sensitive about that sort of thing.

Anyway, Rabbit had started again.

"Well, yes, that's the short answer," he said, "but it misses out a lot." So he carried on:

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*
* THE MEDIUM ANSWER
*
* How many pixels you can fit into a frame of 35mm film depends on how
* many line pairs per millimetre you can achieve with your photography.
*
* The Great Alexander gave, as a reference for his 54 megapixel number,
* a paper by William Oliver.  Now some parts of the paper are hard to
* to understand, but the 54 megapixel number isn't.  On a high contrast
* subject, a medium speed film like Ektachrome can resolve 125 lp/mm.
* Now, it doesn't matter whether your test chart has 125 black lines
* on a white background, or 125 white lines on a black background:
* you need 250 pixels per millimetre to record 125 line pairs.
*
* So a frame of Ektachrome film can hold 36mm x 250 pixels/mm one way,
* and 24mm x 250 pixels/mm the other way.  That's 9000 pixels by 6000
* pixels, or 54 megapixels in all.
*
* ("Hmmm," said Pooh quietly to Piglet, "and that's the EASY part of
* the paper?"
*
* "Zzzz," said Piglet.)
*
* There's nothing wrong with the mathematics.  The only problem is that
* so few of us specialize in photographs of test charts.  Dr Oliver may
* have high contrast subjects in his pathology lab, but the flowers and
* fungi in the woods are all low in contrast.
*
* Fortunately, we can turn to Monaghan's Magnificent Megasite at
*
* http://www.smu.edu/~rmonagha/mf/limits.html
*
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* to find out what can be achieved.  Monaghan the Magnificent points out
* how very hard it is to exceed 50 lp/mm: possible but very hard.
* Ordinary careful amateur photography tends to be more like 40 lp/mm:
* by a similar calculation to the one above a frame of 35mm film can then
* hold 36 x 2 x 40 x 24 x 2 x 40 pixels, or 6 megapixels.
*
* ("Ouch!" said Pooh.)
*
* There are some films that allow higher resolutions on ordinary subjects
* ... provided you have the tripod, the technique, and the lenses to take
* advantage of them.  They are the Kodachromes (which were way ahead of
* their time) at 65 lp/mm, Velvia at 80 lp/mm, and Technical Pan at 100
* lp/mm.
*
* So, instead of the simple 6 megapixel figure of the Short Answer, we
* have different figures for photography at 40, 60, 80 and 100 lp/mm:
*
*    to match normal amateur use of 35mm,          you need  6 megapixels
*    to match meticulous use of Kodachrome,        you need 12 megapixels
*    to match perfectionist use of Velvia,         you need 22 megapixels
*    to match perfectionist use of Technical Pan, you need 35 megapixels
*
* Translating this into 35mm film scanner terms (1 lp/mm = 50.8 DPI):
*
*    to match normal amateur use of 35mm,          you need 2000 DPI
*    to match meticulous use of Kodachrome,        you need 3000 DPI
*    to match perfectionist use of Velvia,         you need 4000 DPI
*    to match perfectionist use of Technical Pan, you need 5000 DPI
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"I have a bad feeling about this," said Eeyore. "We've had the Short Answer and the Medium Answer. I have a sense of dread that there is a Answer and the Medium Answer. I have a sense of dread that there is a Long Answer -- possibly a Very Long Answer -- as well."

"Of course," said Rabbit. "Now that Owl is fully awake, I'm sure he'd like to take over."

Owl fluttered up to his favourite lecturing branch, but before he could begin ...

"Goodness, is that the time?" said Kanga hurriedly. "The smaller animals have to go to bed, and they mustn't miss Owl's interesting talk, so we'll have to stop for this evening. Don't you agree?"

"Zzzz," said Piglet.

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